METAL PROGRESS

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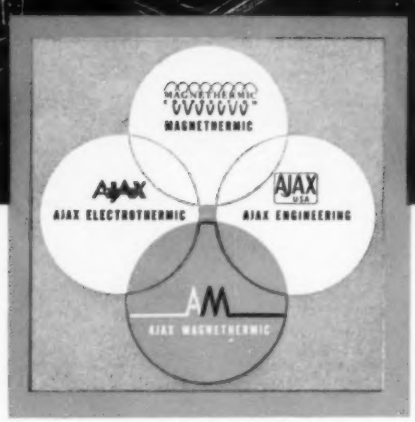

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Metal Progress

September 1960 . . . Volume 78, No. 3

Designed by ED PANOSIAN, an associate of Craig Studios, Cleveland, the cover contrasts a modern blast furnace (Jones & Laughlin, Pittsburgh) with early Egyptian iron smelting (a frame from U. S. Steel Corp.'s film entitled "Rhapsody in Steel").

Dedication Program

Dedication of the National Headquarters of the American Society for Metals, Sept. 14, 1960 ..... following p. 64

Includes historical report on the five founders by Walter Crafts and a biographical memoir of William Hunt Eisenman by Zay Jeffries.

Technical News in Brief

Nuclear Heat Converted to Electricity . . . Imports of Foreign Steel Maintained at High Rate . . . Spherical Powders Made in Inert Atmosphere . . . Oxygen for Steel Plants . . . More on the Oxy-Fuel Lance . . . Zinc Coatings Applied by Tumbling . . . Up Trend in High-Alloy Castings Levels Off . . . Palladium Slows Titanium Corrosion . . . Materials Progress in Applications for Nonmetallics . . . Welding Research Council Surveys Welding Problems . . . Report to Technical Management Updates Progress in Metals 65

Steel Technology on the Move

Residual Elements in Steelmaking, by F. C. Langenberg and J. F. Johnston, Jr. 69

Small amounts of many elements – copper, tin, arsenic and lead, to name a few – remain in steel when refining is completed. Such "minor" elements can have a decided effect on the physical and mechanical properties of the metal. (D11s)*

Revealing Lead Inclusions in Leaded Steels, by Gladys M. Chalfant 77

A new metallographic procedure permits direct microscopic observation and identification of lead inclusions in leaded carbon, alloy and resulphurized steels. The method includes final polishing with an aqueous suspension of gamma alumina that is precisely neutral (pH-7). (M20; AY, *Pb*, 9-69)

Surface Films on Annealed Stainless Steels, by J. H. Waxweiler 80

When stainless steels are bright annealed in hydrogen, the color of the surface film darkens as the dew point of the gas rises. Spectrophotometer and X-ray diffraction tests show that increasing amounts of chromium oxide in the film are responsible. (J23a; SS, 14-62)

Silicon Irons Up to Date, by Weston Morrill 84

In the past decade, crystal-textured material has become widely available, and cube-textured steel is in the wings. The control of stress in sheets for transformer cores now reduces power transformer hum. Improved instrumentation and better analytical techniques have aided the fundamental research needed for these developments. (A-general, M26c, P16; Fe-b, *Si*)

Engineering Articles

Space-Age Beryllium . . . Its Technology, Reported by Robert H. Gassner 88

Learning how to deal with beryllium has proved to be a tough problem. But the efforts are well worth-while because the metal has those properties such as low density, good heat conductivity and high modulus of elasticity which designers need in meeting the challenge of space travel. (A-general, T24, 17-57; Be)

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**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1958*

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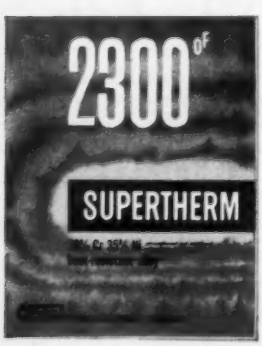

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Metal Progress

Heat Treating Large Steel Castings by Thomas Ditchfield and Robert G. Waite 93

Direct-fired, radiant gas burners maintain a more uniform temperature in the furnace which gives closer control of the operation. This is important for large, irregularly shaped castings which are difficult to heat treat. (J-general, W27g; ST, 5)

Degassing and Cleaning Aluminum With Nitrogen and Nitrogen-Chlorine Mixtures, by Roy F. Gottschalk 97

Removal of hydrogen and entrapped oxides from molten aluminum is more consistent from heat to heat if a special degassing cup is added near the top of the nitrogen lance, or mixtures of chlorine and nitrogen are used. (E25s; Al)

A Homologous Temperature Scale for Metals, by J. H. Westbrook 100

Based on the principle that metallic elements behave similarly in accordance with their absolute melting points, the Data Sheet on p. 100-B can be used in the design of experiments on creep, recrystallization, sintering of powders and other properties which are temperature dependent. (P12)

Chemical Conversion of Metal Surfaces for Improved Corrosion Resistance, by Robert F. Ayres 101

Because it is chemically inactive and possesses low solubility, a conversion coating is a valuable deterrent to corrosion, particularly when it is used as a base for paint. (L14)

Direct Conversion of Nuclear Heat to Electricity, by W. E. Shoupp 108

Thermo-electric materials, used as an array of series-connected thermocouples, offer an exciting possibility for conversion of the almost limitless heat of nuclear fission into electrical energy. Another direct generating system employs the thermionic method. (W11p, 16-61, 16-62; SGA-a)

Explosive Forming and Chemical Milling Discussed, by Robert C. Bertossa 112

These two new methods for forming difficult-to-shape parts are becoming more versatile and more widely used all the time. (G-general, NM-k34, G24b)

"K" Monel Solves Arresting Hook Problem, by Albert R. Mead 117

Special electronic equipment in the tail section of a carrier-based aircraft dictated that its arresting hook be fabricated from a nonmagnetic alloy of high strength. (T24d; Ni-b, 17-57)

Where to Use Microhardness Testing, by Vincent A. Lysaght 121

Not merely a laboratory technique, microhardness testing has definite industrial potential. The method can be used in testing small parts, thin sections (sheet and wire, for example), and hardness near edges of cutting tools. Hardnesses of microconstituents and small areas can also be determined. (Q29q)

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PRESS BREAKS

THIS ISSUE is notable not only because it marks the dedication of our new headquarters building (see following p. 64). It also is the 30th anniversary issue of *Metal Progress!* It was early in 1930 that the late W. H. Eisenman suggested to the Board of Trustees that an engineering magazine be established by the Society — a publication second to none in its field. It was to be no ordinary "Society organ" but an independent engineering journal.

The first thing needed, of course, was an editor. And no ordinary man would suit the purpose. Ernest Thum was sitting behind an editorial desk at the *Iron Age* when Mr. Eisenman offered him the job as editor in June 1930. The only directive the new editor received was this: "Produce an attractive magazine which will bring information about metal progress to engineers and metallurgists engaged in production." Just how to go about this was left entirely

Ernest E. Thum, the Founder-Editor of Metal Progress

in Ernest Thum's hands. Layout, style, scope of material and all phases of production were his responsibilty. It was an opportunity no editor could resist — the chance to *create* a magazine.

Ernest Thum came to the embryonic *Metal Progress* with a metallurgical background ranging from engineering in steel works and copper and lead smelters to teaching the then new subject of metallurgy in fabrication. He had had editorial experience with McGraw-Hill's *Metallurgical and Chemical Engineering* and later on with *Iron Age*. He had organized Union Carbide's technical publicity department. He had boyhood work as printer's devil in his father's print shop, and above all a love of fine printing. Moreover, he had once (for McGraw-Hill) prepared an extensive study for just such an engineering journal and firmly believed that a

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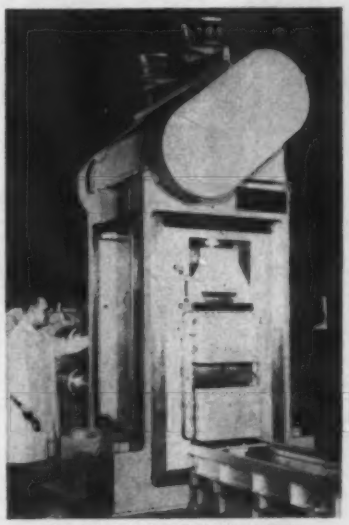

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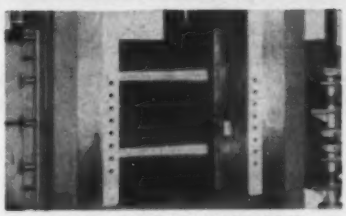

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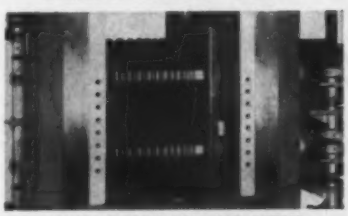

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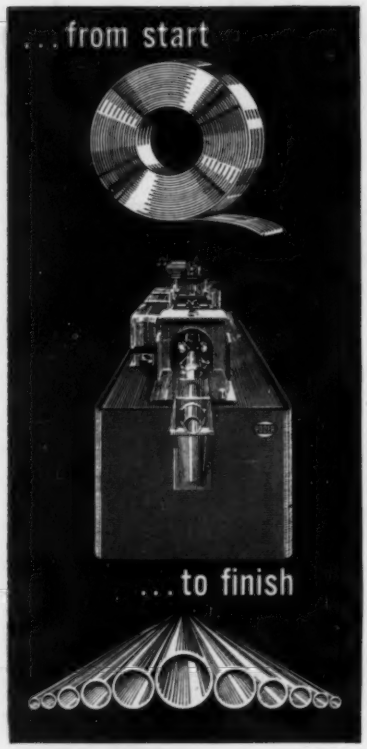

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magazine designed to fill the gap in metallurgical production would succeed. Although hired because of his knowledge of the techniques of his profession and of publishing, Ernest Thum's personal qualifications were just as important. He had an infinite capacity for hard work with the ability to size up a situation quickly and make swift and sound judgments.

The first issue of *Metal Progress* was published in September 1930 – thirty years ago this month – just in time to meet the depression head on. Those days were weathered and by 1936 the magazine was well on its way. Its caliber has been consistently high since its inception and it was an early winner in various contests for editorial appearance and excellence.

Ernest Thum's strong sense of color and design and his love of fine books and fine printing are reflected in the pages of *Metal Progress*. From the start he insisted on the highest standards of layout, printing and typography and maintained that the covers should be artistically attractive to compete with other magazines in the reader's home. Such distinguishing features of *Metal Progress* as the monthly Data Sheet, Critical Points, and the Atomic Age page were inaugurated. The Atomic Age feature, even though it does not deal with metallurgy, was introduced soon after Hiroshima and illustrates a precept close to Ernest Thum's heart – that a good editor must be a leader. The editor's task is to note important developments and point the way to his readers. Thus, already the feature on Atomic Age is occasionally replaced by Astronautic Age.

In recent years the editorial staff of *Metal Progress* has grown with the view of continuing the leadership envisioned by Ernest Thum (now Editor-in-Chief) that "this expanded editorial group will continue the development of *Metal Progress* in pace with the extraordinary tempo of modern technical and scientific advances, and further enhance its prestige and unique position as the Magazine of Metals Engineering". New features have been added to better serve this age of exploding scientific industry and to assist those in technical management who guide the metalworking industry.

This anniversary is also a fitting time to reflect on a question we editors are frequently asked: "Why are you, a graduate metallurgist and an engineer, in the publishing business?" Our answer is simple and forthright: As technical editors we feel we are contributing more to our industry, the Nation and our profession than we could do if our efforts went into other directions. We feel that accurate dissemination of engineering information is more important today than ever before. Our national progress and defense of our homes depend upon it. The interpretation of new technological knowledge in its applications to industrial processes enables it to be used as soon as possible. Equally important – the regular perusal of the pages of technical magazines permits engineers to continue to educate themselves. We feel that we are teachers on a post-graduate level, not only for those years when the student must translate his book learning into day-by-day decisions, but also through all life while the mind is still expanding.

We believe that the engineering training and experience of the editors on the staff of *Metal Progress* will continue to bring more and more profitable reading to you during the next 30 years . . . and will enable us to live up to the directive of founder-editor Thum to "collect and print the vital information about the expanding world of metals, necessary for the wide-awake engineer to meet his ever-widening obligations – all directed toward the paramount necessity of maintaining our Nation the Home of the Free".

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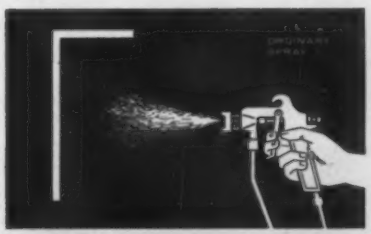

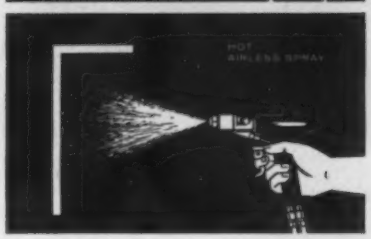

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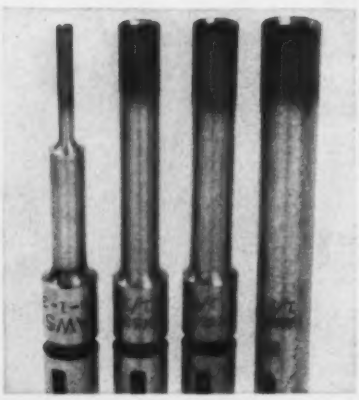

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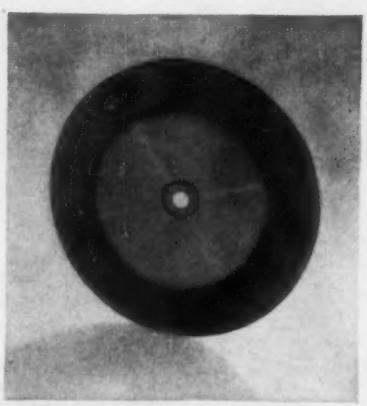


RUBBER SKIVING KNIVES

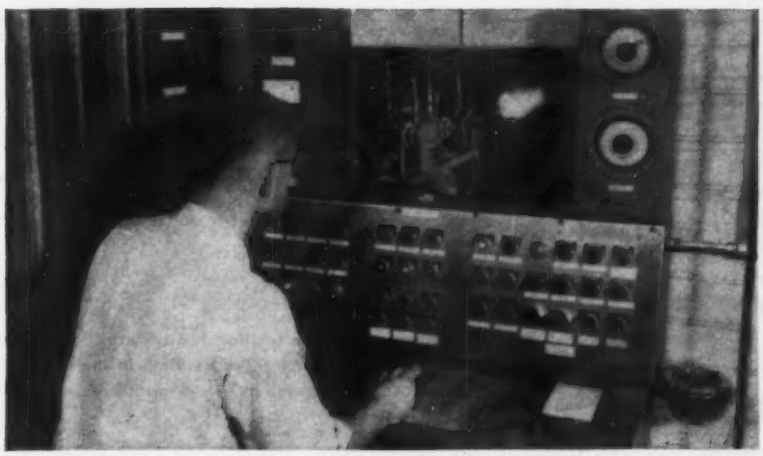
Before Flame-Plating, skiving knives used in the rubber industry had to be sharpened after every shift. Since adoption of Flame-Plating the service life of this tool has been increased 15 times. A sharp edge is always present, due to a *self-sharpening* effect.

SEAMING CHUCKS

LINDE's Flame-Plating is an important time-and-money-saver for the abrasive-resistant, tolerance-stable seaming chucks used by major canners. Operating life is more than 4 times longer. Chucks, when worn, can be salvaged, replated, and returned to use.

for Metal Parts – Metal-Coated by

PLATING



THE "LINDE" FLAME-PLATING GUN—and how it works

In LINDE's revolutionary Flame-Plating process, precise quantities of oxygen, acetylene, and tungsten carbide powder—representing "powder and shot"—are fed into the gun by a special mechanism. The gun is aimed at the areas to be coated, then fired by remote control. Precision-controlled rapid-firing (4 per second) builds up the coating to the desired thickness. The as-coated smoothness of 125 microinches rms can be finished down to better than 1 microinch rms finish.

PHYSICAL DATA—FLAME-PLATED COATINGS

COATING DESIGNATION	LW-1	LW-1H	LW-5	LC-1A	LA-2
Approx. Composition by weight	Tungsten Carbide + 6% to 8% Co	Tungsten Carbide + 13% to 16% Co	25% WC + 7% Ni + mixed W-Cr Carbides	85% Cr_3C_2 + 15% Ni-Cr	99% + Al_2O_3 (gamma)
Hardness Vicker's (VPN_{100})	1200 to 1450	1050 to 1150 VPN 70 to 71 R_c	1000 to 1200 VPN	850 VPN	1000 to 1200 VPN
Maximum temp. in oxidizing atmosphere	1000°F.	1000°F.	1400°F.	1800°F.	1200°F. to 1800°F.
Coefficient of thermal expansion	4.0 x 10 ⁻⁶/°F. Avg. 70 to 1000°F.	4.7 x 10 ⁻⁶/°F. Avg. 70 to 1000°F.	4.6 x 10 ⁻⁶/°F. Avg. 70 to 1400°F.	6.4 x 10 ⁻⁶/°F. Avg. 70 to 1800°F.	3.9 x 10 ⁻⁶/°F. Avg. 70 to 1832°F.
Modulus of Rupture	67,000 psi	80,000 to 106,000 psi	40,000 psi	75,000 psi	22,000 psi
Modulus of Elasticity	44 x 10⁶ psi	42 to 40 x 10⁶ psi	17 x 10⁶ psi	22 x 10⁶ psi	16 x 10⁶ psi
Porosity	0.5%	0.5 to 1.0%	0.5%	0.5%	1.0%
Specific Gravity	14.2	13.2	10.1	6.54	3.45
Specific Heat	0.048	0.056	0.070	0.127	0.196
Thermal Conductivity	5.3 at 500°F.	5.3 at 500°F.	3.8 at 500°F.	4.3 at 500°F.	0.86 at 500°F.
Main features	Extreme wear resistance	Excellent wear resistance + increased resist. to mechanical and thermal shock.	Excellent wear resist. to higher temps. Improved corrosion resist.	Good wear resist. at high temp. or in corrosive media. Resists flame impingement.	Excellent resist. to wear, chem. attack and high temperature deterioration.

TYPICAL FLAME-PLATING APPLICATIONS

BEARINGS — sleeve, roller, gas
BLADES — aircraft turbine; doctor blades for papermaking
BLOCKS — anvil
BUSHINGS — ball piston pump
CHUCKS — seaming
CUTLERY — household
CUTTING, INDUSTRIAL — rubber, plastic, skiving knives, foods, paper, slitter knives, chipper knives, discontinuous chip-abrasive materials
DIES, TOOLING — cold-forming; coring punches, core rods, sizing punches, capstans
DOGS — sewing machine feed; gripping dogs
DRILLS — paper, acoustical tile, twist
GAGES — plug, ring, air
GUIDES — wire, textile, machine
HYDRAULICS — pistons, liners, valve plates, wobble plates, metering valves, servo valves, slippers
MANDRELS — wire-forming
PARTS — sintered
PISTON RINGS
PLATES — valve, wear
SEALS — turbine engine, pump
SURGICAL — needle holders and shears
VALVES — aircraft

MP-9

Linde Company, Flame-Plating
270 Park Avenue
New York 17, New York

I am interested in Flame-Plating for the following application(s):

_____

_____

_____

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE STATE_____

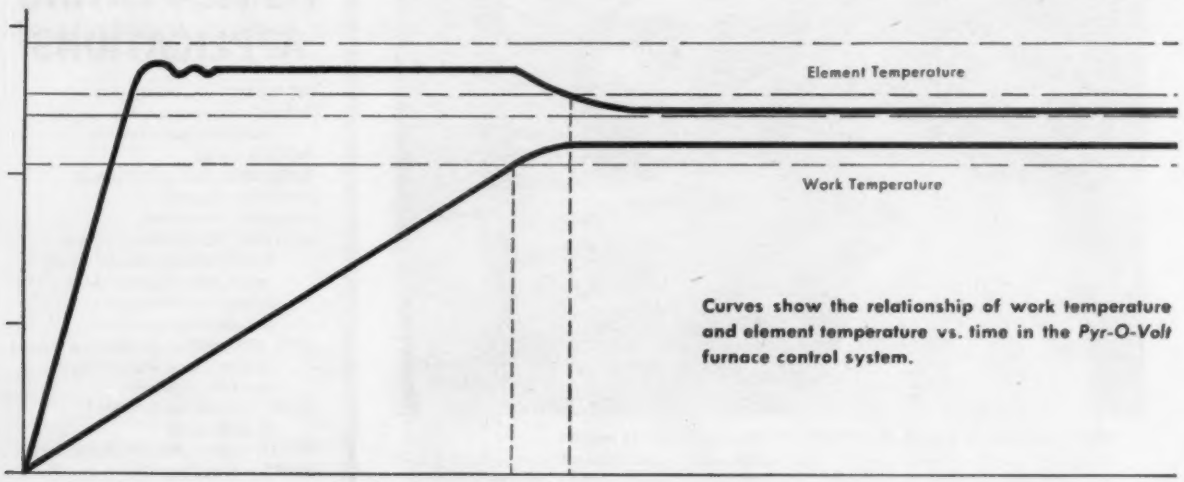
LINDE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

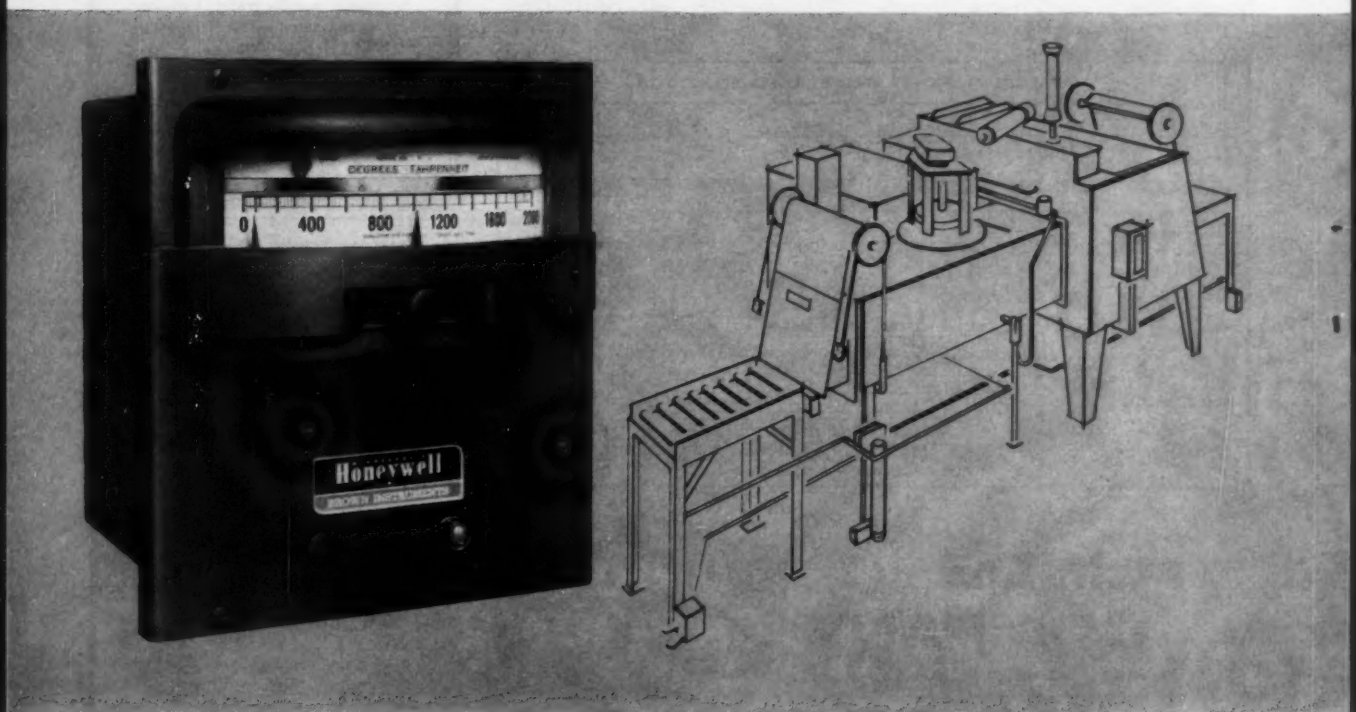
LINDE and UNION CARBIDE are trade-marks of Union Carbide Corporation.

Circle 1243 on Page 48-B

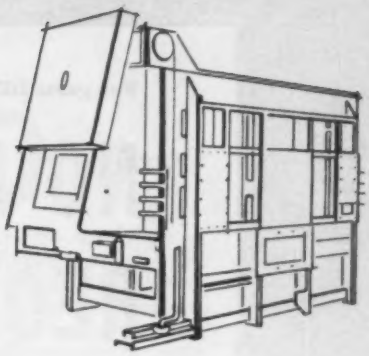
Electric furnace control overshoot, protects



Curves show the relationship of work temperature and element temperature vs. time in the *Pyr-O-Volt* furnace control system.



system prevents heating elements



Here's the simplest, most economical way to bring electric furnace temperatures up to work level rapidly and safely using saturable reactor control.

This accurate Honeywell system holds fast-rising furnace temperature to a safe value as the slowly-increasing work temperature approaches its control point. The system consists of two *Pyr-O-Volt* controllers and a magnetic amplifier. Both controllers feed signals to the magnetic amplifier until work temperature reaches set point, then the work temperature controller assumes primary control of the system.

This relatively inexpensive system requires minimum maintenance, as no relays or other mechanical switching means are used. Both controllers have provision for fail-safe thermocouple burnout protection. In addition, automatic current limiting can be supplied with the system should you require extra protection for molybdenum heating elements.

Your nearby Honeywell field engineer can give you complete details on applying this system to advantage in your plant. Call him today . . . he's as near as your phone.

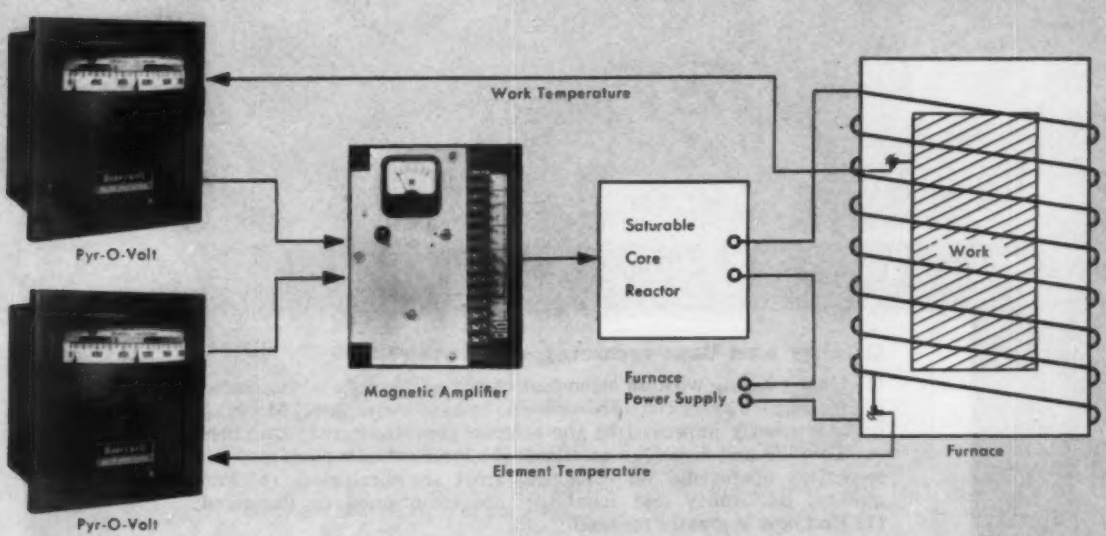
MINNEAPOLIS - HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

First in Control

SINCE 1885

75th YEAR — PIONEERING THE FUTURE



Circle 1244 on Page 48-B

For parts DIRECT from machining to assembly..dependably

NO HEAT TREATING REQUIRED with

La Salle e.t.d. 150

elevated temperature drawing

ALLOY STEEL BARS

GUARANTEED 150,000 PSI tensile strength

- **e.t.d. 150 alloy machines better than heat treated in-the-bar alloy steels!**
- **e.t.d. 150 alloy has exceptional uniformity!**
- **e.t.d. 150 alloy simplifies production!**

Quality and Cost-reducing Advantages!

(1) Heat treating with its attendant costs and hazards is eliminated. (2) No quench cracks or distortion due to heat treating. (3) Machinability is greatly improved by the acicular pearlitic-ferritic structure. (4) Tool life and finish are excellent. (5) Production is simplified . . . secondary operations following heat treat are eliminated. (6) Part quality, uniformity and reliability are maintained or improved. (7) End cost is greatly reduced.

Ask for a sample test bar

Send a blueprint . . . or write us giving application details.

What is e.t.d. 150 alloy?

"e.t.d." 150 is an alloy steel bar made by the exclusive and patented Elevated Temperature Drawing process to a guaranteed minimum tensile strength of 150,000 psi and a hardness of Rc 32 minimum. Strength and hardness are uniform across the section of the bar. The uniform pearlitic-ferritic structure of "e.t.d." 150 alloy eliminates the problems associated with non-uniform quenched and tempered structure. Ideal for shafts, gears, pinions, fasteners and other parts now being heat treated or made from heat treated in-the-bar materials.

SPECIFICATIONS

Ultimate Tensile Strength	150,000 psi minimum*
Yield Strength (.2% offset)	130,000 psi minimum*
Proof Stress (.01% offset) (1½" Rd. and smaller only)	120,000 psi minimum*
Elongation—Approx. only	10% -20%
Reduction of Area—Approx. only	35% -45%
Brinell Hardness Number	302 minimum*
Rockwell "C" Hardness	32 minimum*

*GUARANTEED MINIMUMS. In event of disagreement between hardness and tensile strength, the tensile strength shall govern.

Use this coupon to ask for helpful data bulletin

La Salle STEEL CO.
1424 150th Street
Hammond, Indiana

Please send Helpful Data Bulletin No. 22, "e.t.d. 150 alloy steel bars eliminate heat treating of parts."

Name_____

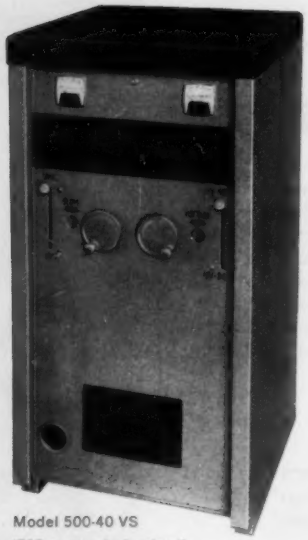
Title_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 1245 on Page 48-B



Model 500-40 VS
(500 amp rated output)

For jobs where only the best will do—

NEW GLENN V/S VARIABLE SLOPE

CONSTANT VOLTAGE POWER SUPPLIES

for all consummable-electrode automatic and semi-automatic welding processes, including:

MIG - SHORT ARC
SUBMERGED ARC - MAGNETIC FLUX

New GLENN V/S power supplies are totally new from basic transformer design to their exclusive new linear slope control. They can be precisely "tuned" to the exact arc characteristics needed to produce any type of metal transfer and deposition desired. The result is improved weld quality, appearance, speed and economy.

Model 300-40 VS
(300 amp rated output)

WHEN SPECIFICATIONS ARE CRITICAL and weld quality, uniformity and appearance must be kept high, you'll be hours and dollars ahead to specify GLENN V/S power supplies. Why not get the facts? Write us today for literature, specifications; please address Dept. 136

Basic features

1. **NEW TRANSFORMER DESIGN** increases efficiency improves voltage regulation and minimizes effects of line voltage fluctuations.

2. **STEPLESS VERNIER SLOPE CONTROL** provides continuous linear slope control from flat no-slope to maximum slope; in two overlapping ranges.

3. **EXTENDED OUTPUT VERNIER VOLTAGE RANGE** provides effective dc welding (loaded) voltages from approximately 8 to 42 volts, depending on slope settings.

GLENN PACIFIC

POWER SUPPLY CORPORATION

703-37th Avenue • Oakland 1, California

Originators of CV Power Supplies

Eastern Office
221 Dukes Rd., Rahway, N. J.

Midwestern Office
640 So. York, Elmhurst, Ill.

✻ GLENN Balanced Wave Power Supply for TIG Welding ✻ GLENN Manual and Stud Welder Power Supply ✻ GLENN Arc Gouger Power Supply ✻ GLENN Constant Potential Welder for "Gang" Manual Welding ✻ GLENN Industrial Power Supplies and Heavy Duty Variable Voltage Transformers

3

Circle 1246 on Page 48-B

BETHLEHEM STEEL
New!
Now Bethlehem forges every hardened steel roll from vacuum-degassed steel!

Bethlehem vacuum-degassed steel minimizes the hazard of roll breakage

Pint size, king size, every in-between size. Now Bethlehem forges *every* hardened steel roll from vacuum-degassed steel.

Pioneer in "vacuum casting"

Bethlehem pioneered the development and use of vacuum-degassed ingots for highly stressed applications in the electric power, atomic energy, and other industries.

Our advanced steel-pouring techniques now permit us to pour molten steel from a furnace ladle to a secondary ladle within a vacuum chamber, and thereby remove harmful gases (we can also pour directly into a mold in the vacuum chamber). The secondary ladle is then taken out of the chamber and ingots of suitable size for hardened steel rolls can be cast under a blanket of inert gas.

Less gas means sounder steel

Because the vacuum-casting method reduces the volume of hydrogen and other gases, the steel is sounder, tougher, and cleaner than air-cast steel. It is this greater internal soundness which reduces the hazard of roll breakage.

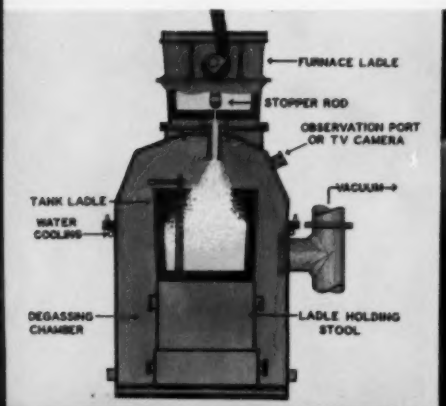
Over 350 rolls now in service

In the past several years, we've produced and shipped over 350 large, vacuum-degassed hardened steel rolls. The outstanding performance of these rolls confirms our own production experience, which clearly proves the superior soundness of vacuum-cast rolls as compared to air-cast rolls.

Fast delivery . . . no extra cost

You have everything to gain (less roll breakage), nothing to lose (no price extra) by making your next purchase of hardened steel rolls Bethlehem vacuum-degassed rolls. Deliveries are excellent. Our sales offices are ready to give you the *whole* interesting story of this new Bethlehem development. Call or write the office nearest you today. Or write to us at Bethlehem, Pa.

STEEL IS TAPPED from the furnace into the furnace ladle. The furnace ladle is then attached to the vacuum tank, and the molten metal pours through a vacuum-tight seal into either a secondary ladle or a mold inside the degassing chamber. If poured into a ladle, ingots can be subsequently cast from this ladle under a blanket of inert gas.



TV TELLS HIM WHAT'S GOING ON. One TV camera peers inside the high-vacuum chamber into which the hot steel is gushing and shows the stream coming from the furnace ladle (top screen). Another camera, whose picture appears on the bottom screen, shows the action of the hot steel as it flows into either the secondary ladle or the mold set up inside the vacuum tank.

ULTRASONIC SOUND WAVES, pitched so high you can't hear them, penetrate every inch of the Bethlehem vacuum-degassed roll you see here. The waves relentlessly search out any possible inner discontinuities which, if present, would be indicated on the screen. When the Bethlehem inspector gives his OK, you can rely on the soundness of that roll.

BETHLEHEM VACUUM-DEGASSED ROLLS are made for every application—cold-rolling steel sheet, strip, tinplate, and non-ferrous metals. Every roll meets your specifications *exactly* on size, shape, hardness, and finish.

BETHLEHEM STEEL

BETHLEHEM STEEL

CHECKING EVERY DETAIL is more than a routine habit in the making of Bethlehem vacuum-degassed forged rolls. It's done with an extra measure of thoroughness, extra care—from the analysis of the steel to the critical inspection of the finished product.

These are the new symbols of quality for hardened-and-ground forged steel rolls

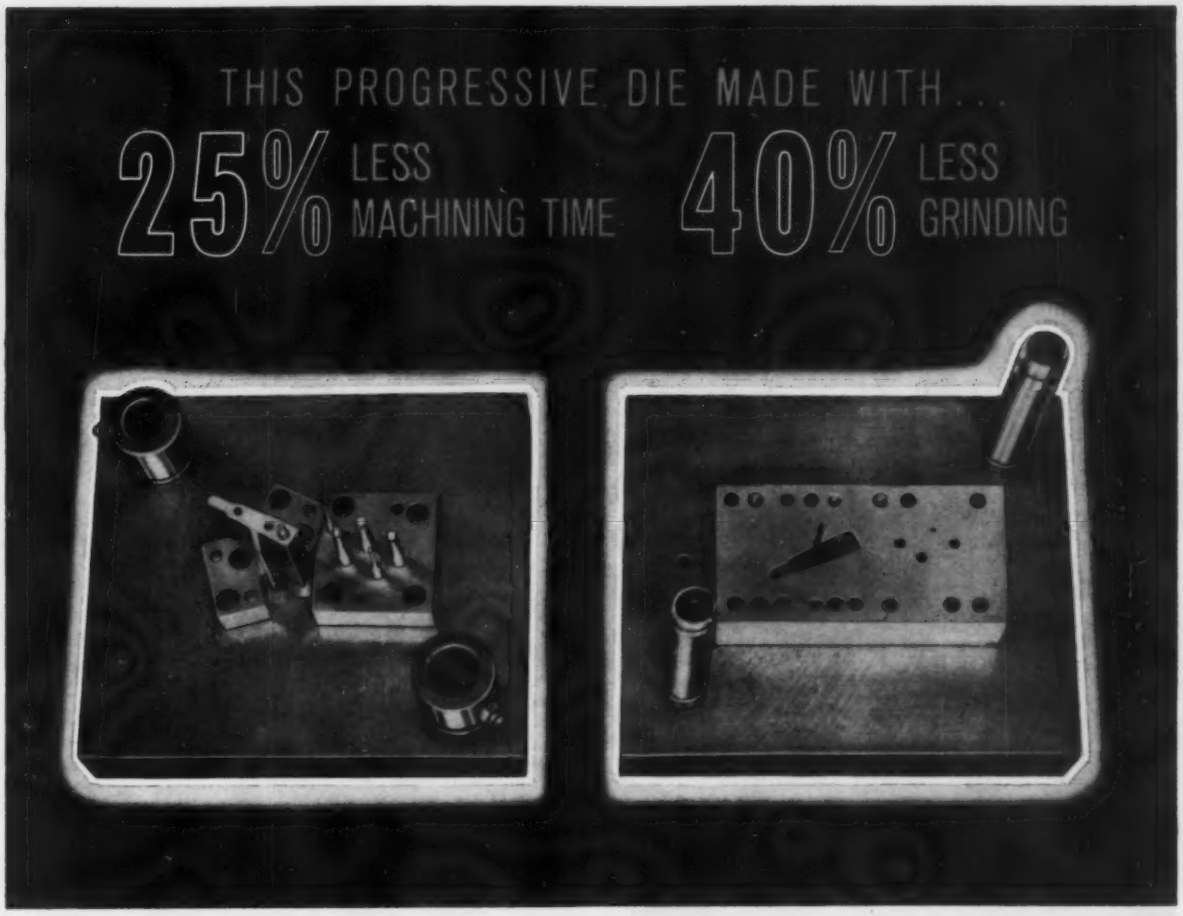
LOOK FOR THIS LABEL on the packing of the hardened steel rolls you buy. It's your guarantee that your rolls are forged from Bethlehem vacuum-degassed steel . . . steel that minimizes the hazard of roll breakage in your plant.

LOOK FOR THIS "V" STAMP on the ends of the rolls you buy. . . . "V" is for vacuum. You'll find this permanent identification on every Bethlehem roll from now on . . . because from now on Bethlehem forges hardened steel rolls *only* from vacuum-degassed steel.

For strength
. . . economy
. . . versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



LO-AIR TOOL and DIE STEEL

*Low Temperature · Air Hardening**

. . . CUTS PRODUCTION COSTS

Accurate Machine and Tool Company of Roselle Park, N.J., reports savings of 40% in grinding and 25% in machining time on this progressive die—through the use of LO-AIR, the tool and die steel that is easy to machine —has least distortion in hardening.

On oil hardening tool steels, previously used for this die, .015" was allowed on sides for grinding and .005" in jig bored holes before heat treating. With LO-AIR they found it safe to allow not more than .0025" on sides and no extra in holes before hardening—making great savings possible.

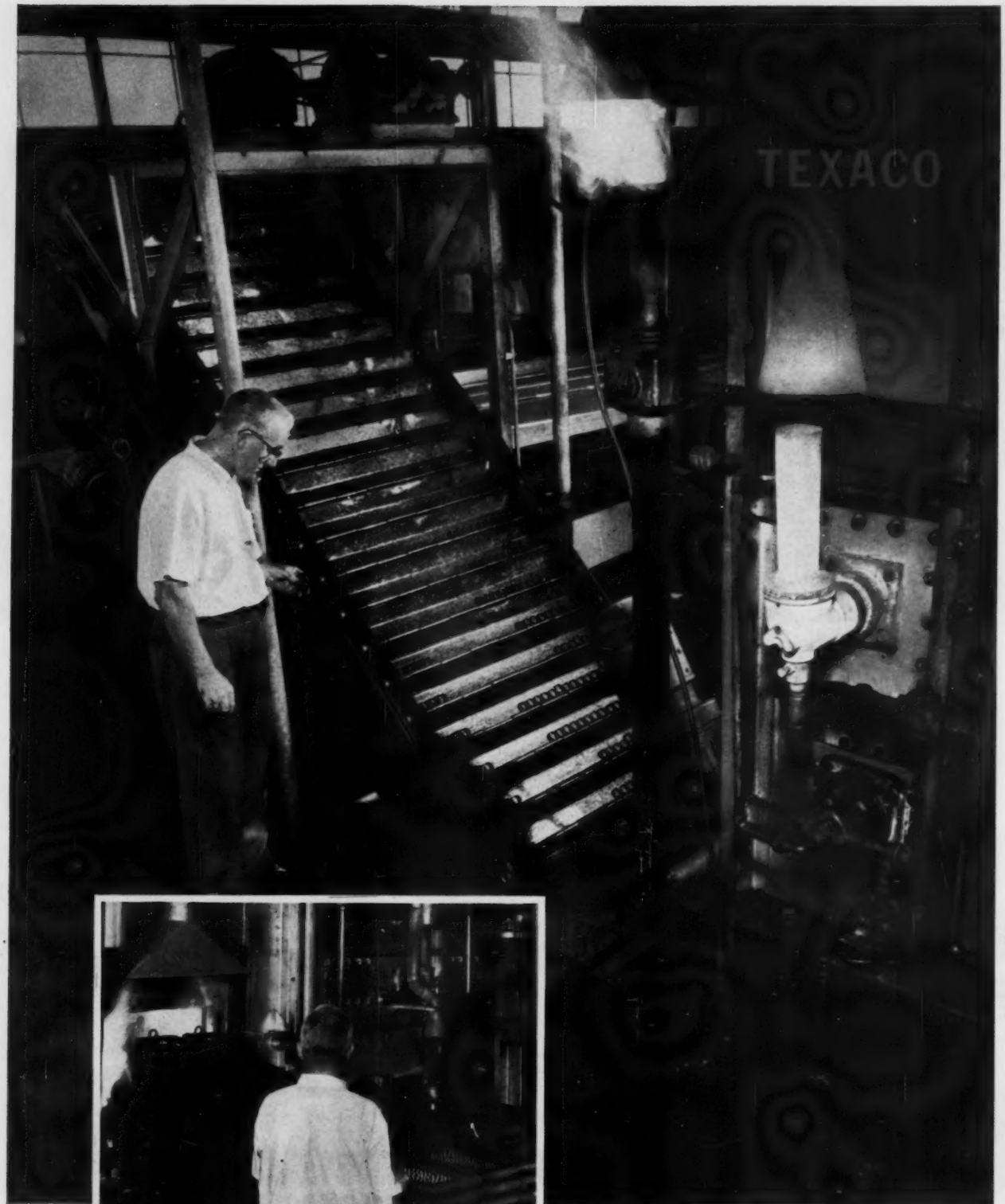
For complete information, write today for Performance Report No. 20. Also, we will gladly send you a copy of our 12-page LO-AIR brochure on applications, properties and other technical data. For immediate delivery of LO-AIR, call our nearest sales office or warehouse. Complete stocks available.

**U.S. Pat. No. 2,355,224*

UNIVERSAL CYCLOPS
UC STEEL
STEEL CORPORATION
EXECUTIVE OFFICES: BRIDGEVILLE, PA.

TOOL STEELS • STAINLESS STEELS • HIGH TEMPERATURE METALS

Circle 1146 on Page 48-B



Photos taken at Hoover Ball and Bearing Company, Ann Arbor, Mich., show (left) parts going into heat treat furnace and (above) coming out of Quenchtex bath.

QUENCHTEX OILS GIVE UNIFORM HARDENING IN THE PIECE

with improved grain structure... no darkening of metal...longer bath life...

The proper choice of a quenching oil depends on the analysis of the steel being used and the hardness desired, among other factors.

A properly chosen quench for any given steel should remove heat fast in the high temperature range, and at a lower rate as the temperature drops through the low ranges where the metal becomes brittle and subject to stress. Because steels vary widely in analysis, Texaco offers three separate QUENCHTEX OILS—each with a different cooling curve.

The differences in cooling rate between the three QUENCHTEX OILS are functions of their composition:

- **QUENCHTEX 500**—a conventional or straight mineral oil of low viscosity;
- **QUENCHTEX 510**—a medium-speed oil blended with special additives;
- **QUENCHTEX 520**—a high-speed oil blended from refined paraffin base crudes plus additives.

GET THESE PROVED ADVANTAGES WITH QUENCHTEX OILS

- Stability at recommended temperatures
- High resistance to evaporation loss and chemical change which occur on contact with hot metals
- Resistance to oxidation which causes contamination, oil and metal discoloration, uneven hardening
- Low drag-out and evaporation loss for longer oil life and greater economy
- **Compatibility with other quenching oils. You can begin using Quenchtex now—regardless of the oil now in your tanks.**

A Texaco Metalworking Specialist will be glad to take a sample of the oil you are now using for testing by Texaco's Research Laboratory. A cooling curve will be run on the sample and the compatible QUENCHTEX OIL will be recommended for make-up. For further information contact the nearest of the more than 2,300 Texaco Distributing Plants or write:

☆ ☆ ☆

Texaco Inc., 135 East 42nd Street, New York 17, N. Y. MT-50

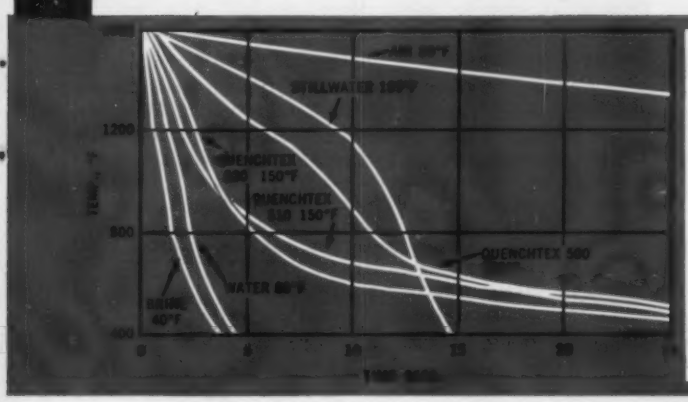


Chart shows cooling rates of several quenching media including QUENCHTEX 500, 510 and 520.

TEXACO MARQUENCH FOR HOT OIL QUENCHING

For products where full hardness combined with minimum distortion is required—gears, ball and roller bearings, bearing races, etc.—hot oil quenching with MARQUENCH can help reduce the number of rejects, increase product load capacities, and in some cases permit closer tolerances before quenching.

TEXACO

Throughout the United States
Canada • Latin America • West Africa

Circle 1147 on Page 48-B

RIEHLE LOS FATIGUE TESTING MACHINES

First to combine static and dynamic testing capabilities

Featuring a basic system of compatible components, new RIEHLE-LOS Hydraulically-Actuated Fatigue Testing Machines permit far greater variety and versatility in testing programs than is possible with any other machine. Available in models with capacities ranging from 12,000 to 300,000 pounds, new RIEHLE-LOS machines can be used to perform dynamic tests as well as conventional static tests.

Using the basic system of console, pulsator and loading unit, both alternating and fluctuating loadings on test specimens can be applied. Infinitely variable frequencies between 125 and 1000 c.p.m. can be obtained while the machine is being operated by the pulsator. A slow-cycle control accessory can be connected to provide frequencies from about 5 to 100 c.p.m.

By including RIEHLE recording and strain measuring instrumentation in the system, conventional static testing can be performed on the new machines. Tension and compression tests are done in the same space, so transition from one to the other is easily accomplished.

Other accessories which can be integrated to extend the utility of the machines include a programmer to automatically vary load levels and frequency and General Purpose Testing Cylinders for testing large parts and assemblies.

Installation is simplified because new RIEHLE-LOS Fatigue Testing Machines are floor models, requiring no pit.

OTHER RIEHLE TESTING MACHINES: Hydraulic and Screw Power Universal Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testing Machines, Portable Hardness Testers for Rockwell Readings, etc.

Circle 1148 on Page 48-B

Riehle® TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

"One test is worth a thousand expert opinions"™

MAIL COUPON TODAY FOR ADDITIONAL INFORMATION

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-960, East Moline, Illinois

Please send me Bulletin RF-10-59 on the new RIEHLE-LOS Fatigue Testing Machines.

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Divisions of American Machine and Metals, Inc.

TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY • GLASER-STEERS CORPORATION

NEW PRODUCTS

NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS

Heat and Corrosion Resistant Materials

Cobalt-Base High-Tungsten Superalloy

"WI-52", a superalloy from *WaiMet Alloys Co.* has good ductility, corrosion resistance, and high-temperature strength in the 1800° F. range. The alloy has excellent foundry characteristics and is used in casting aircraft gas turbine blades by the investment technique. Average stress-rupture life at 1800° F. and 15,500 psi. is 73 hr.; elongation is 17% in 1 in. The stress-rupture life is 20% greater at 1800° F. than X-40 alloy (A.M.S. 5382). WI-52 shows good resistance to extreme thermal shock. The alloy contains 11% W and 21% Cr plus controlled amounts of C, Mn, Si, Ni and Fe to insure full development of elevated-temperature properties.

For further information circle No. 895 on literature request card, p. 48B

Cutting and Forming Equipment

Precision Machining at 300,000 RPM

The *Ashcombe Co.* has announced a new air-driven cutting and grinding instrument, which reduces the time required to produce small holes, grooves, slots, and die cavities. The "Airotor" will grind holes as small as 0.025 in. to a tolerance of ±0.0001 in. It will machine hard metals, ceramics, glass, and carbides at increased efficiency. The tool can be used on operations that are difficult to reach, since the Airotor head is only ⅜ in. in diameter by ½ in. long. The instrument can be used as a hand tool, or is easily adapted for use with jig borers, lathes and milling machines. The Airotor operates on an air supply of 1¼ cfm. at 40 psi. A control unit regulates and filters the air and adds a fine lubricant to it. The instrument operates at a speed which dissipates heat rapidly, thus permitting good control and accuracy.

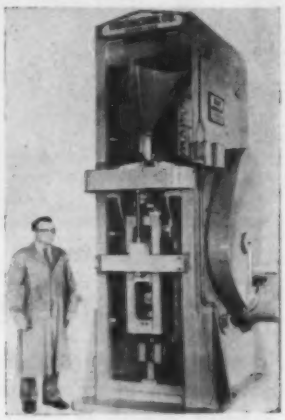
For further information circle No. 896 on literature request card, p. 48B

Mist Spraying Unit

Unimist, Inc. has introduced an improved mist spraying unit for accurate control of metalworking operations. The precise control of mist volume and spray pattern aids machining, drawing or extruding because heat is dissipated uniformly and at the proper rate. Tolerances and surface finishes can therefore be effectively controlled. The "Unimist" metering blocks are mounted at the point of application, where the operator can adjust metering screws for optimum air and liquid flow. The unit comes complete with 2-gal. tank, pressure regulator, gage and safety valve.

For further information circle No. 897 on literature request card, p. 48B

Automatic Powder Compacting Press



Designed for automatic and continuous production of solid compacts from powdered or granular material, a 125-ton mechanical press can produce a variety of parts, such as ceramic insulators, iron cores, brake facings, self-lubricating bushings and tungsten carbide products. Parts can be produced up to 6 in. in diameter, by 6 in. long and at a rate of 12 per min. A cam-pause mechanism permits the formed compact to be held under the pressure of both punches while it sets, resulting in uniform compact size and higher density. *Kux Machine Co.*

For further information circle No. 898 on literature request card, p. 48B

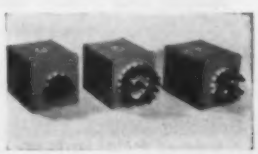
Program Controller for Drop Hammer

The "Ceco Blowmatic", designed for use with an air-lift, gravity-drop hammer, improves forging quality and production, because a standard forging method can be set up for every job. After the blow patterns are set, the operator need only initiate the cycle. At the end of each cycle, the hammer stops automatically, with the ram in raised position. The operator's work is made easier since he does not have to treadle the hammer to change stroke length. *Chambersburg Engineering Co.*

For further information circle No. 899 on literature request card, p. 48B

Industrial Heating Equipment

Automatic Igniter Control

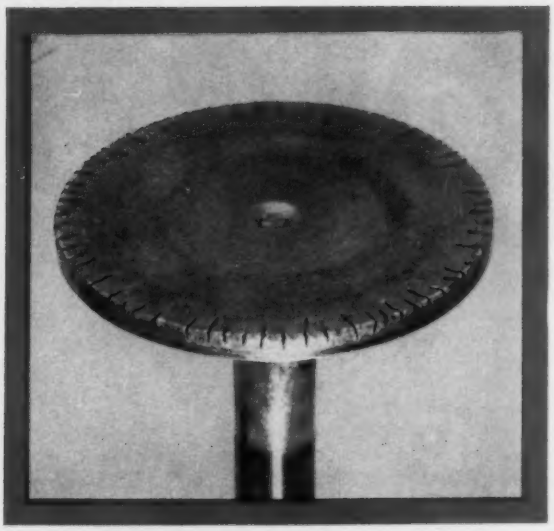


The "Ignitifier", a multi-burner igniter control manufactured by *Protection Controls, Inc.*, will automatically fire up a network of gas burners in furnaces or boilers.

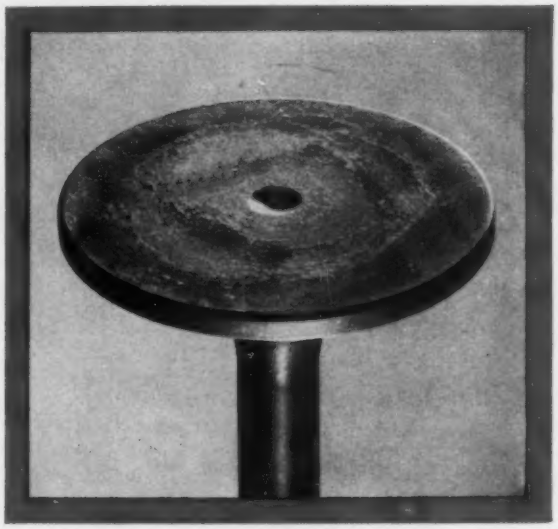
Accelerated Engine Test Comparison Proves

EATON SUPER-ALLOY VALVES LAST MANY TIMES AS LONG

AS VALVES MADE FROM COMMONLY USED ALLOYS



COMMONLY USED ALLOY
Failed at Less than
600 Hours

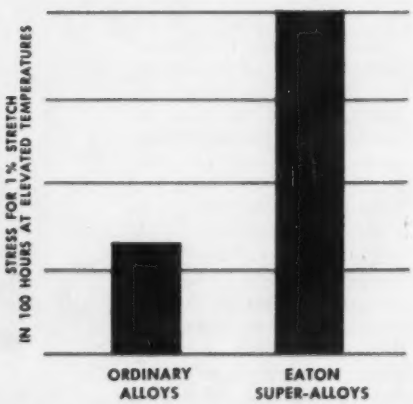


EATON SUPER-ALLOY
In Excellent Condition
after 3000 Hours

To meet the requirements of extreme heavy duty service, Eaton has developed unique production methods for the making of exhaust valves of super-alloys possessing exceptionally high hot-strength and corrosion resistant properties. These Eaton Super-Alloy Valves are "custom tailored" to meet the specific requirements of the engines for which they are designed.

As a pioneer in the development of valve designs and materials which have added thousands of miles to valve life expectancy, Eaton has made such important contributions as sodium cooled valves, seat-faces of high-alloy materials, aluminized valves, and now super-alloy valves.

If you build engines—either gasoline or diesel—for heavy duty applications such as motor trucks, buses, earth moving machinery —it will pay you to discuss the advantages of Eaton Super-Alloy Valves with our engineers.



The results of laboratory tests represented by the above graph indicate the superior hot-strength of Eaton Super-Alloys over commonly used exhaust valve materials.

EATON

VALVE DIVISION
MANUFACTURING COMPANY
BATTLE CREEK, MICHIGAN

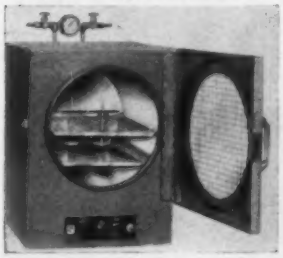
PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Truck and Trailer Axles • Truck Transmissions • Permanent Mold Iron Castings • Automotive Heaters and Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Forgings • Leaf and Coil Springs • Dynamatic Drives and Brakes Powdered Metal Parts • Gears • Variable Speed Drives • Speed Reducers • Differentials • Centralized Lubrication Systems

Circle 1149 on Page 48-B

A high-speed ignition system fires 32 burners within 3 sec. The positive contact switch eliminates arcing and contributes to long life. A special timing unit will activate the unit for continuous, intermittent, or variable-timed ignition. Standard units operate at 5000 or 6000 volts, and are available in multiple-igniting capacities of 8, 12, 16, 20, 24, 28 and 32.

For further information circle No. 900 on literature request card, p. 48B

High-Temperature Vacuum Oven

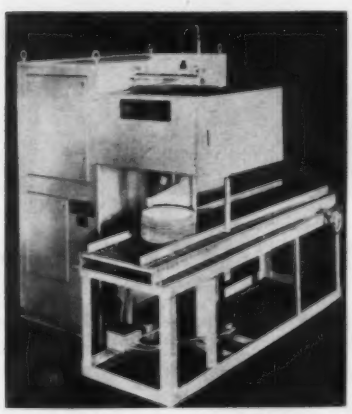


The "Super-Temp Duo-Vac" laboratory oven has a range from 72° to 500° F. within an 11 in. diameter by 12 in. deep vacuum chamber. The unit heats to maximum temperature in 1 hr. with uniformity maintained within ±1° F. at all settings. Radiant heating elements are completely enclosed. A large safety glass window permits a full view of furnace interior. *Labline, Inc.*

For further information circle No. 901 on literature request card, p. 48B

Induction Annealing of Blanks

Ajax Magnethermic Corp. is offering a 60-cycle induction heater for annealing aluminum blanks, which may be circular, rectangular or oval. Using the appropriate coil, the machine will accept blank sizes that range from 4 to



30 in. in diameter. Heating times will vary from 1 to 40 min., depending on blank size and stock height (12 in., max.). The operation is automatic, but the cycle can be started and stopped at will. One man can easily operate two units. When annealing blanks at 850° F., the capacity is 1000 lb. per hr.

For further information circle No. 902 on literature request card, p. 48B

Induction Heating Unit

This versatile "Ther-Monic" machine by *Induction Heating Corp.* can perform hardening operations at high or low frequencies and has dual facilities for oil and water quenching. A spindle in the machine will raise, lower or rotate the work in and out of the heating station. An indicating timer controls heat and quench cycles automatically. The unit can also be used as a reservoir for oil or water recirculating systems, or for drop-quench systems.

Circle No. 903 on literature request card

Radiation Monitor and Control

"Pyrotel", a noncontacting radiation monitor and control for the low-temperature range of 500 to 1200° F., has an optical system that can detect small or moving targets. It is ideal for control of such operations as extrusion, plastic forming, heat treating, soldering and brazing. It can monitor objects being treated in a controlled atmosphere, in vacuum, or in an induction furnace. The Pyrotel has a repeat accuracy of ½ to 1% of scale and is extremely fast – responding in milliseconds. The instrument can actuate a power relay, signal, control, or temperature recorder. *Mason Instrument Co.*

Circle No. 904 on literature request card

Cleaning and Finishing Equipment

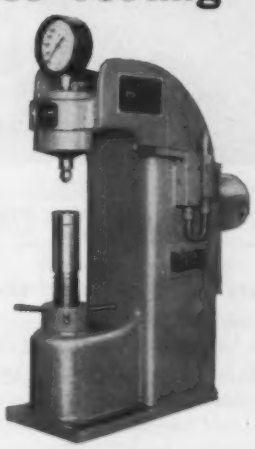
Aluminum Surface Treatment

"Chemlok 720", a chemical surface treatment for aluminum, increases the adhesion of paints, lacquers, and enamels. The adhesion obtained is stronger than the coating applied – the paint film will fail cohesively rather than

New Ease in Hardness Testing

with this Steel City Brinell Machine

● LOW-COST ● HYDRAULIC
● MOTORIZED
● POSITIVE ACCURACY



Now, even smaller shops can do Brinell hardness testing with a bench-mounted machine combining operating economy, control simplicity, high accuracy. Tests made with only finger-tip pressure. Operators cannot apply load too fast or overload. Stroke of ¾" permits anvil height to remain fixed when testing series of pieces of almost equal thickness. Load, provided by motorized hydraulic pump, is accurately controlled by time-tested relief valve. Load verified on sensitive hydraulic load gage.

Distributors in most major metalworking areas

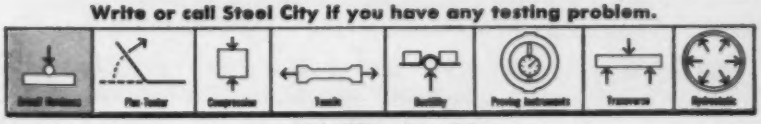
Steel City Testing Machines Inc

8811 Lynden Ave., Detroit 38, Mich.

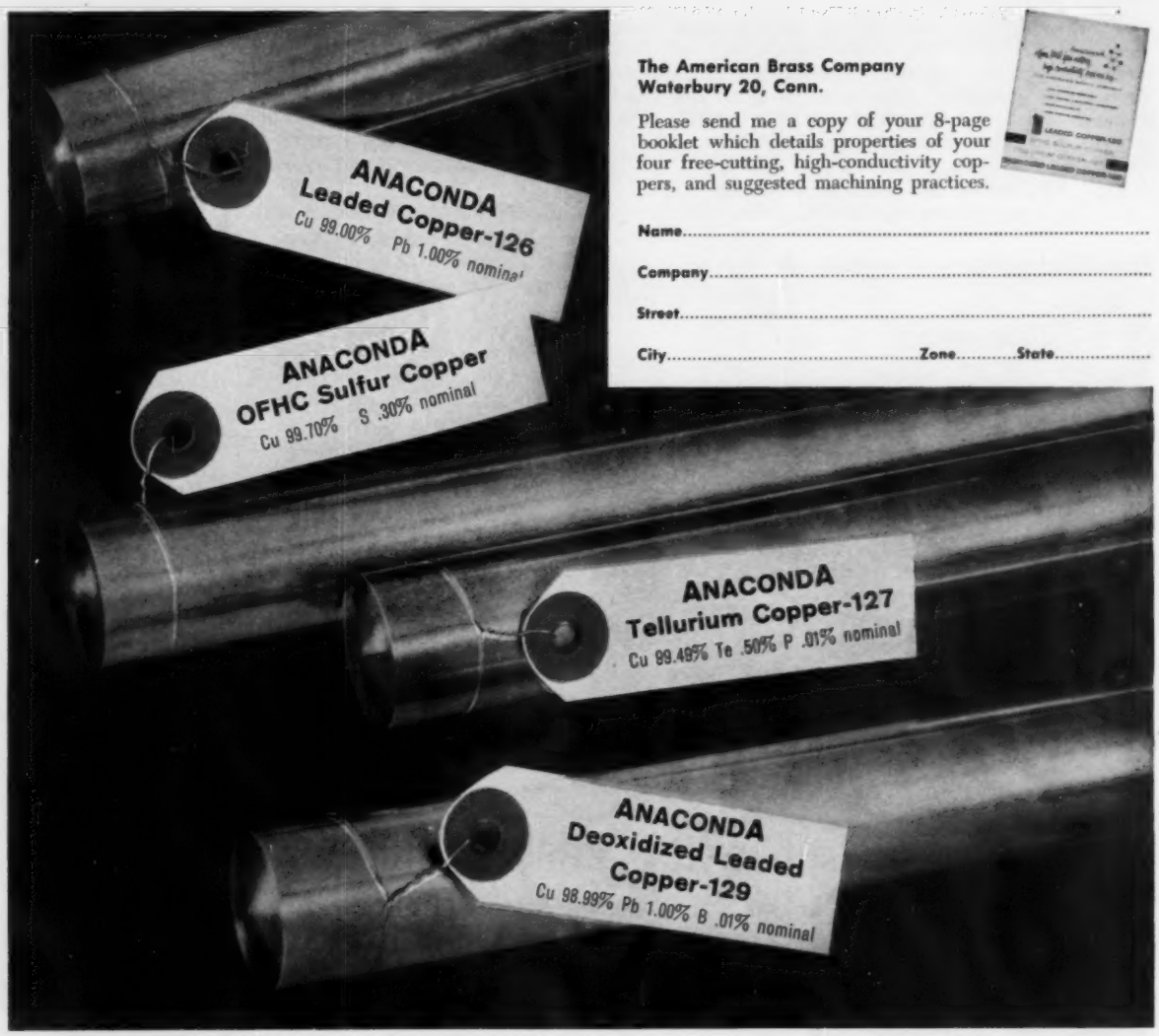
ALSO AVAILABLE IN DEAD WEIGHT MODEL

Either bench or floor-mounted, hand-operated or motorized. Operation is simple, fool-proof, with highest accuracy assured. Brinell loads can be changed frequently without loss of accuracy.

Write or call Steel City if you have any testing problem.



Circle 1150 on Page 48-B



The American Brass Company
Waterbury 20, Conn.

Please send me a copy of your 8-page booklet which details properties of your four free-cutting, high-conductivity coppers, and suggested machining practices.

Name.....

Company.....

Street.....

City.....**Zone**.....**State**.....

4 ways to cut the cost of high-conductivity parts

There are now four free-cutting, high-conductivity Anaconda coppers that broaden the combinations of mechanical, physical, and fabricating properties available for boosting production and cutting costs of high-conductivity parts. They are furnished chiefly in rod and bar, but are available also as extruded shapes and, except for the leaded coppers, die-pressed forgings of simple design. All have good cold-working properties.

Leaded Copper-126 and Deoxidized Leaded Copper-129 have slightly higher electrical conductivity—98% IACS annealed, 95% IACS, minimum. The difference between them is that Alloy 129, being deoxidized, is not subject to hydrogen embrittlement when annealed or furnace-brazed in reducing atmospheres. Neither leaded alloy is recommended for hot working.

Tellurium Copper-127 and OFHC* Sulfur Copper have an electrical conductivity rating of 95% IACS annealed, 90% minimum. Both may be extensively hot worked and neither is subject to hydrogen embrittlement. Tellurium Copper-127 has the advantage of retaining its mechanical properties at temperatures higher than those tolerated by the other free-cutting coppers—and hence is widely used in the welding and cutting-tip field.

The free-cutting coppers may be machined at cutting speeds approaching those used for machining Free-Cutting Brass. For Tellurium Copper-127, however, carbide-tipped tools are recommended as the inherent copper telluride particles cause somewhat greater tool wear.

*Registered Trademark of American Metal Climax, Inc. 6047 Rev.

ANACONDA®

FREE-CUTTING HIGH-CONDUCTIVITY COPPER PRODUCTS

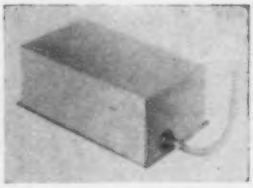
Made by The American Brass Company

Circle 1151 on Page 48-S

strip off the aluminum. This means that paints will adhere until completely weathered away, assuring long-term protection. Coated aluminum parts can tolerate greater deformation during manufacture. The Chemlok 720 process is fast, simple, economical, and produces no sludge. Results are uniform and reproducible and the process is adaptable to batch or continuous operation with spray or immersion equipment. *Hughson Chemical Co.*

For further information circle No. 905 on literature request card, p. 48B

Immersible Transducer



Designed to convert present cleaning and degreasing tanks to ultrasonic power, an immersible transducer made by *Harris Transducer Corp.* is magnetostrictive, and can be operated continuously at 300° F. Low voltage requirements minimize the shock hazard. The system operates at 22 kc. for maximum cleaning efficiency and minimum noise. Made of stainless steel, long life and continuous performance are assured.

For further information circle No. 906 on literature request card, p. 48B

Protective Coating of Fiberglas Flakes

Owens-Corning Fiberglas Corp. has developed a spray coating of "Fiberglas" flakes which provides corrosion protection for metals and other materials. One 20-mil thick coating consists of 50 layers of fiberglas flakes – equivalent to 50 coats of paint. Accelerated weathering tests show no deterioration. The coating is a mixture of fiberglas flakes, resin, filler, accelerator, and pigment (if desired for decorative effect). Applications include chemical and oil storage tanks, industrial ducting, as well as concrete sewer lines, flooring, and block walls. No mixing is required. After spraying, the coating is rolled to orient the flakes and eliminate pinholes.

Circle No. 907 on request card

Vibratory Barrel Tumbling

Electromagnetic vibration is utilized in *Syntron Co.'s* barrel tumbling machines for deburring, cleaning and descaling. Controlled directional vibration keeps parts and media agitated and working 100% of the time. This assures thorough cleaning in shielded areas. The vibration amplitude can be varied while the same frequency (3600 per min.) is maintained. The units are available in three sizes: 0.4, 1 and 6-cu.ft. barrel capacity.

For further information circle No. 908 on literature request card, p. 48B

Electroplating Brightener

A powdered vegetable gum derived from okra, when added in small quantities to the electroplating bath, provides a brightening action on nickel plate. It may also be used in plating silver, copper and cadmium. In many cases, brightness is increased to the extent that no further buffing or polishing is required. Organic acids, salts such as sodium chloride, and surface-active agents have little effect on the properties of okra dispersions. However, trivalent ions such as aluminum will coagulate an okra gum dispersion. *John A. Manning Paper Co., Inc.*

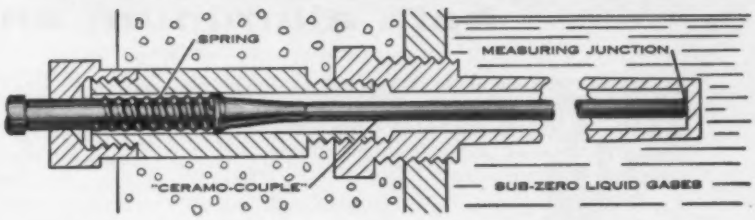
For further information circle No. 909 on literature request card, p. 48B

Welding and Joining

Ultrasonic Seam Welder

An ultrasonic seam welder has been developed by *International Ultrasonics, Inc.* for use in joining thin, refractory metals for space vehicles and for applications in foil rolling, packaging, and foil condenser and transformer manufacture. A self-tuning feature reduces reliance on operator skill and improves weld uniformity and reliability by automatically adjusting the welding frequency to its optimum

Sub-Zero Ceramo-COUPLE Solves Condensation Problems



"Ceramo" versatility has also solved a key problem of *sub-zero temperature measurement*—condensation. Caused by wide temperature differences between ambient temperatures and the thermocouple measuring point, condensation can penetrate thermocouple insulation and short out conductors.

Overall Metal Sheathing of "Ceramo" thermocouple wire completely encloses conductors and ceramic insulation—shutting out moisture effectively. Sheathing itself is stainless steel or other corrosion-resistant material.

Spring-Loaded Construction of T-E's sub-zero probe holds contact point firmly against thermowell end—counteracting effects of expansion and contraction from temperature changes.

Applications—Liquid oxygen, nitrogen, ammonia and similar applications. Conductors are either Copper-Constantan or Chromel-Constantan for measuring temperatures as low as —320° F.

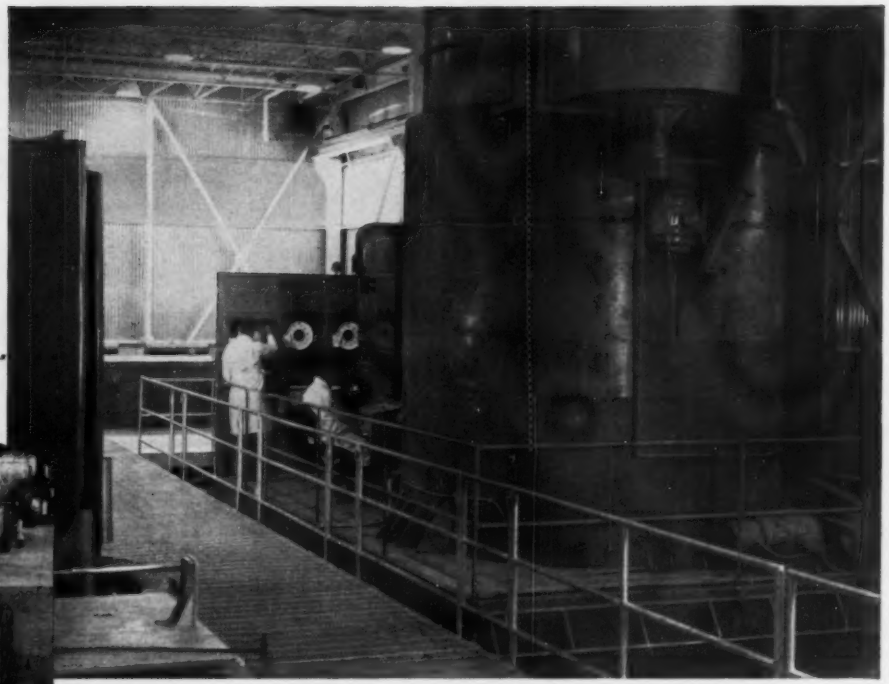
Write For Bulletin 52-16

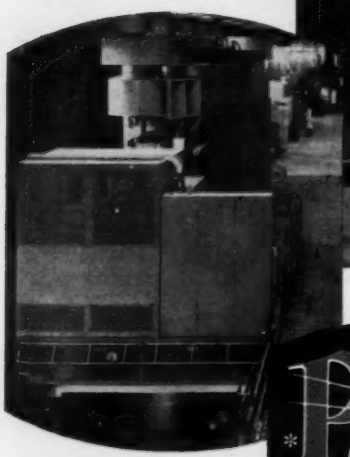
Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.
Brampton, Ont.

Circle 1152 on Page 48-B

At The Marquardt Corporation's Ogden Division..





this NEW

DUAL RANGE GANTRY FURNACE

heat treats both aluminum and steel alloys

Now in operation at the Marquardt Corporation's Ogden facility, this giant Pacific Gantry Furnace provides dual heat ranges to permit heat-treating aluminum or steel alloys. Conversion from steel to aluminum treating takes a minimum of 4 hours.

Inside working diameter of the furnace is 72″ with a depth of 120″. Operation is automatic—the furnace operator on the gantry platform is seated at a control console as the furnace, mounted on tracks, moves over the quench tanks.

When heat-treating aluminum, temperature uniformity is held to ±5°F. in a temperature range of 250°F. to 1400°F. A temperature range of 1200°F. to 2000°F. is used for the steel alloys with a uniformity of ±15°F. This excellent uniformity is achieved with three zones of control using saturable reactors.

When set up for aluminum alloys the furnace may be used for Marquardt parts where large cylinders and cones can be solution-treated and water-quenched. Steel alloys to be heat-treated include large rings of AISI 4340, 310 Stainless Steel cylinders and various types of Die Steels.

This Pacific Gantry Furnace at Marquardt is one of a number of unusual, special purpose furnaces Pacific Scientific has custom-designed and built for the aircraft and missile industry—that produce savings in materials handling time as well as first-cost and maintenance.

Whatever your needs, a Pacific engineer will be glad to discuss them with you. Write or call today!

Pacific ®TRADE MARK

Creative Development and Manufacturing in Furnace Design

GAS OR ELECTRIC INDUSTRIAL HEAT TREATING EQUIPMENT

PACIFIC SCIENTIFIC COMPANY

LOS ANGELES
SAN FRANCISCO
SEATTLE
PORTLAND, OREGON
ARLINGTON, TEXAS
SAN DIEGO
DENVER

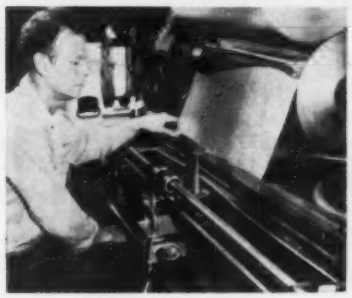
PACIFIC SCIENTIFIC COMPANY, P.O. Box 22019, Los Angeles 22, Calif.

☐ Please send me information on custom designed furnaces.
☐ Please send me your FREE Brazing Catalog.
☐ Please send me a copy of your new catalog and full information on Pacific Heat Treating Equipment.

Name_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 1153 on Page 48-B

value – despite variations in material thickness or cleanliness. The welder produces continuous seams, stronger than the parent metal, which do not



bulge at the joint. Material as thin as 0.00017 in. and as thick as 0.006 in. – as well as dissimilar metals and metals of different thickness – has been successfully joined without difficulty.

Circle No. 910 on request card

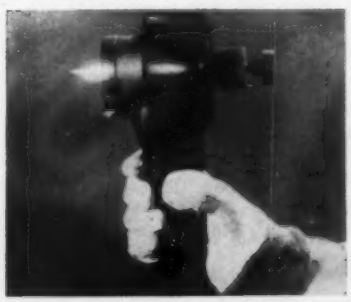
Epoxy Resin Adhesives

A two-component epoxy resin adhesive that cures at room temperature under contact pressure is available from *Minnesota Mining & Mfg. Co.* Service range is −67 to +160° F. Shear strength of metal-to-metal assemblies ranges from 2300 to 3200 psi. at 75° F. The adhesive has high creep strength and good resistance to water, hydraulic oils and aromatic fuels. The material is excellent for honeycombs because it flows easily into voids and fillets.

Circle No. 911 on request card

Low-Temperature Plasma Spray

A new design for a plasma-jet spray gun permits materials with melting points between 300 and 30,000° F. to be deposited. Low melting materials such as zinc, lead, soft solders and epoxy resins may be sprayed. High-purity coatings are assured because the equipment is operated with inert gas. *Plasmadyne Corp.* also claims that it is now technically feasible to spray low-melting organic compounds.



Circle No. 912 on request card

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on the complete

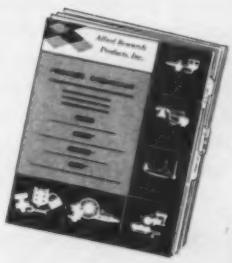
Allied Research

Line for Metal Finishing

PROCESSES AND PRODUCTS FOR CORROSION PROTECTION, PAINT BASE, DECORATIVE FINISHING

A complete line including IRIDITE Chromate Conversion Coatings for non-ferrous metals, IRILAC Clear Protective Coatings for all metals, ISOBRITE Chemically Different Plating Brighteners and ARP Process Chemicals.

If one of our present products does not meet your needs, we'll be glad to work with you to find an answer to your problem.



EQUIPMENT AND COMPLETE FINISHING SYSTEMS

Includes information on WAGNER Silicon and Selenium Rectifiers, WAGNER Auto-Loaders for transfer of racks and parts from conveyors to plating machines or between conveyors, Automatic and Semi-Automatic Plating Machines, Barrels, Tanks and other equipment.

Also includes information on Process Engineering Service—complete plant design, specification and installation.

CHEMICALS AND SUPPLIES

Price and delivery information on a wide variety of plating room necessities, including ROLL-TOP Zinc anodes, FLAT-TOP copper anodes, ELECTROCOP Flat Copper anodes, Cadmium and Tin Anodes, Acid Replacements, Buffs, Chemicals, Cleaners and Maintenance Materials.

NICKEL RECASTING SERVICE

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IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

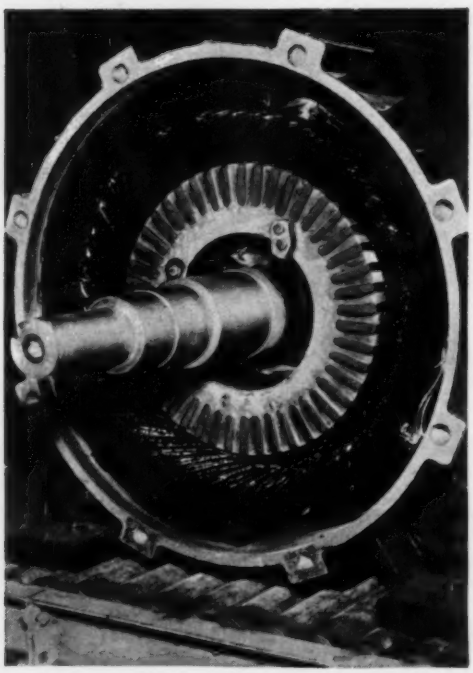
Circle 1154 on Page 48-B

Copper Alloy Bulletin

BRIDGEPORT BRASS COMPANY

Bridgeport "CONTACT BRONZE" Cuts Costs of Electrical Spring Contacts by 25%

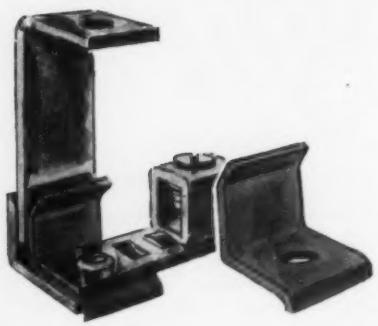
This outstanding Bridgeport alloy offers many of the superior mechanical qualities of phosphor bronze at considerably less cost...with a superior electrical conductivity rated at 22% IACS at 68° soft. Designed to meet the exacting standards of the electronics industry, Bridgeport "Contact Bronze" (Alloy 92) maintains spring properties even after difficult forming operations. Add corrosion resistance and "Contact Bronze" is a guarantee of efficient and reliable performance throughout your product's service life. Here are a few examples:



ELECTRIC MOTORS

The 100-hp 4-pole motors driving extruder-type machines in a dog-food plant were causing frequent production breakdowns. The material processed was so highly viscous that the motors were stalling, jogging and burning out. To meet the high torque, high slip necessary to minimize stalls and also to provide the high thermal capacity required, Allis-Chalmers Company designed a special motor rotor utilizing Bridgeport "Contact Bronze" in place of copper. Burnouts from overload were eliminated and the performance of the "Contact Bronze" motor was so excellent that Allis-Chalmers received an order for another sixteen of the same type.

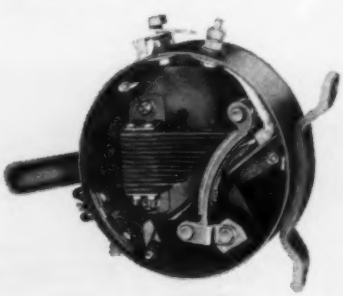
PRESSURE CLIPS



American Electric Switch Division, Clark Controller Company, found that "Contact Bronze" fitted their needs for a lower cost alloy for pressure clips. Its electrical conductivity, corrosion resistance, spring and formability properties were more than comparable with other alloys...at 25% less cost.

TRAILER TRUCK BRAKING SYSTEM

Warner Electric Brake & Clutch Company manufactures an ingenious electric brake system for heavy-duty trailer trucks. Through a graduated series of Bridgeport "Contact Bronze" leaves, it allows the driver to adjust torque instantly and smoothly to suit load and road conditions. The conductivity and performance-proved spring properties of "Contact Bronze" provide added safety and long-haul reliability.



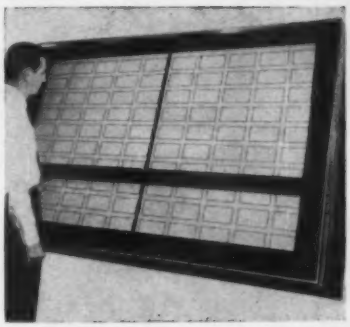
✓Check the Savings INVESTIGATE "CONTACT BRONZE"

Electronic and mechanical devices, switch gears, circuit breakers, contacts, terminals are just a few of the applications. There are thousands of others. Call your nearest Bridgeport Sales Office or write Dept. 8309, for full details of Bridgeport Contact Bronze. Bridgeport Brass Company, Bridgeport 2, Conn.

Circle 1155 on Page 48-B

Inspection and Control Equipment

400-Point Recorder



The "K-Logger", a new type of multiple recorder and annunciator, has been introduced by *Keinath Instrument Co.* It records on one chart all the variables in a complex process. The K-logger makes from 10 to 400 analog recordings at rates up to 10 points per sec., and displays them in 4 by 6 in. chart frames. Both electric and pneumatic signals can be mixed on one recorder. When removed from the K-logger, the traces, in four colors, become a permanent record of the experiment or operation.

For further information circle No. 913

Remote Micrometer

J. W. Dice Co. announces the development of the "Carson-Dice Remote Mike", an automatic micrometer capable of taking measurements to ten-millionths of an inch. The unit includes an accurate micrometer head operating on the screw-thread principle plus an electronic control console. Digital read-out is displayed on a counter. The head, which exerts negligible pressure on the work, can be remotely zeroed in at any point within its measuring range of one inch.

For further information circle No. 914 on literature request card, p. 48B

Stereomicroscope

A training microscope which permits instructor and trainee to examine a specimen simultaneously is manufactured by *Bausch & Lomb.* Components include two "StereoZoom" microscopes and two accessories: 0.5 × lens attachment for greater working distance and a vertical illuminator which acts as a beam splitter so both viewers see the same field with equal clarity. If desired, the two basic microscope components can be used independently for routine examinations.

For further information circle No. 915 on literature request card, p. 48B

Production and Casting Equipment

Vacuum Diffusion Pump

The "H6-1500", a 6-in. fractionating oil-diffusion pump provides 70% more speed, 275% higher fore-pressure tolerance, 40% less backstreaming, and lower ultimate pressures than its predecessor. The fractionating jet assembly has one ejector and three diffusion stages. The speed peaks at 1500 liters per sec. between 6×10^{-4} and 5×10^{-4} mm. Hg. Fore-pressure tolerance is 700 microns at blank-off and 600 microns at full load. Blank-off measures 5×10^{-6} mm. Hg. *NRC Equipment Corp.*

For further information circle No. 916 on literature request card, p. 48B

Molten Metal Pumps

The "Gusher Model 150XE" motor-driven pump can handle liquids and molten metal up to 1300° F. The pump is cooled by circulating water, or by compressed air when handling molten metal up to 800° F. The unit includes a lift loop—for simple installation and easy removal when desired—and features interchangeable impellers. When higher heads are required, impellers with diameters up to 7 in. can be installed. *Ruthman Machinery Co.*

For further information circle No. 917 on literature request card, p. 48B

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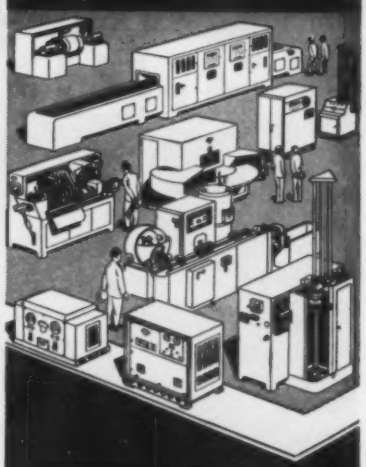

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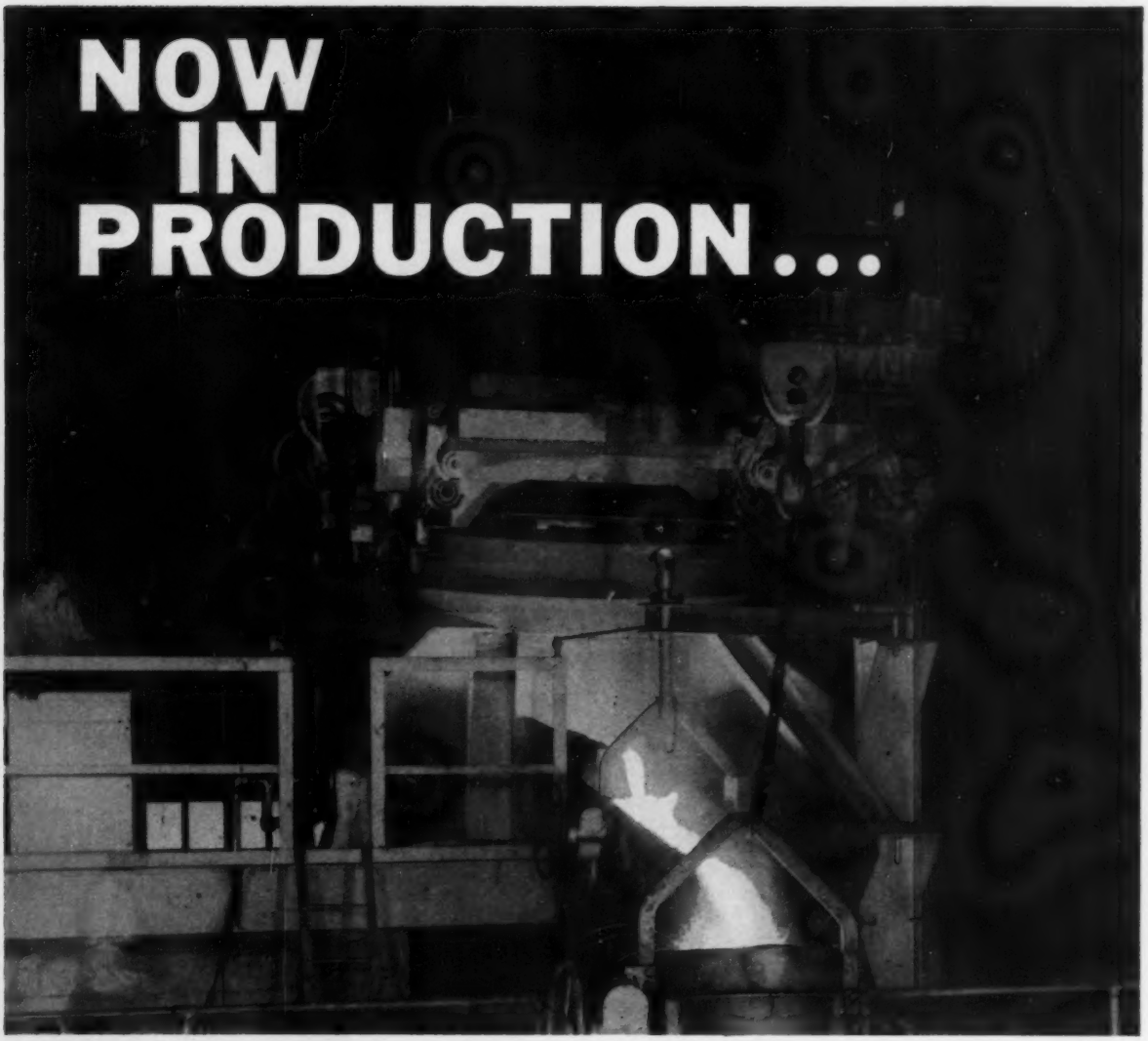
Circle 1156 on Page 48-B



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Completely automated, this plant is bringing maximum economy, on-time delivery, and outstanding quality to the benefit of our customers.

Electronically controlled equipment provides you with the exact hardness, on the exact job you specify.

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Circle 1157 on Page 48-B

VCA carries a complete line of distributors, too! A full line of ferroalloys isn't all that Vanadium Corporation offers. Consider, for a moment, VCA's full line of *Distributors*. They're centered for service at strategic locations, to meet your needs completely and efficiently from local warehouses. When you insist on Vancoram Products, you're settling for nothing less than the best. And the best possible service comes with them! Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N.Y. • Chicago • Cleveland • Detroit • Pittsburgh.

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VANADIUM
CORPORATION OF AMERICA
Producers of alloys, metals and chemicals

Circle 1158 on Page 48-E

WRITE YOUR OWN RELIABILITY INSURANCE HERE...

Wherever metals are being cast, forged, or fabricated, the important factor of reliability can be assured by specifying R_XMet brand alloys. Whether we ship shot for making castings, billets for forging, or special welding rod, the R_XMet label on the alloy means more consistent performance in the finished product.

At WaiMet, metallurgical reliability and quality control are more than words—they are integral parts of a dedicated approach to making better alloys. We dig a little deeper than most to find out why an alloy behaves as it does, then define new limits of chemistry to guide the production of every heat. Result: alloys with reproducible, consistently better mechanical properties.

In almost every alloy we make there is some WaiMet improvement in processing or heat treatment technology that will mean better reliability insurance for the user.

HERE ARE TYPICAL REASONS WHY ALLOY USERS SPECIFY R_X MET®

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410	Aircraft wing hinge	Cleaner melting and tailored chemical composition.
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Hortonspheres built of USS "T-1" Steel for Compania Cubana Del Nitrogeno, S. A., Matanzas, Cuba. Designed, fabricated and erected by Chicago Bridge & Iron Company.

Weight cut 50%

In USS "T-1" Steel pressure vessels. Each of these two Hortonspheres in Matanzas, Cuba, has a capacity of 8,750 barrels of anhydrous ammonia. They are 45.5 feet in diameter and each shell weighs about 311,350 pounds. By designing them with USS "T-1" Constructional Alloy Steel, to an allowable working stress of 32,400 psi, the plate thicknesses were reduced to 1.109 inches and 1.075 inches. This is about 50% less than if A212-Grade B fire box quality steel had been used.

Result: Only 363 tons of USS "T-1" Steel were needed for both tanks, reducing by one-half the amount of steel that would otherwise have been required. Freight, handling, welding and erection costs were less—and the user got a stronger, tougher vessel with an overall saving in cost.

Fabrication steps: Plates of USS "T-1" Steel in widths of 78 inches and 115 inches and lengths up to 19 feet 2-½ inches were shaped cold and field stress relieved. Column plates and some shell plates were stress relieved in the shop. Electrodes used in field welding were low hydrogen type of the E110 strength level and all field welds were 100% radiographed. With a minimum yield strength of 100,000 psi, plus toughness, weldability, and high resistance to impact abrasion, USS "T-1" Steel is ideally suited for many applications throughout industry. Write for our latest booklet. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and "T-1" are registered trademarks
Hortonsphere is a registered trademark of Chicago Bridge & Iron Company

This mark tells you a product is made of modern Steel

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
National Tube—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company
United States Steel

USS

This forging may cradle the greatest source of energy on earth

One of the great scientific investigations of all time is now in progress, as we strive for a controlled *fusion* reaction. If we succeed, man will be able to generate a limitless amount of energy using deuterium fuel, a hydrogen isotope, available in inexhaustible quantities from the sea.

Princeton University carries on the study with their Stellarator-type experimental devices. The Model-C Stellarator Facility now nearing completion will cost $35 million and consists of an 8-inch-diameter, 40-foot-long, racetrack-shaped tube to control the reaction. Required ignition temperature is in the order of 100 *million* degrees. Any solid material will evaporate at that temperature, so the hot ionized gas will be confined in a magnetic field of *50,000* gauss in the Model-C Stellarator. The equipment is supported by USS Quality Forgings of Type 305 Stainless Steel.

Altogether, U. S. Steel supplied 17 of these stainless steel forgings, fully annealed, to Allis-Chalmers Manufacturing Company, major contractor for the new Model-C Stellarator.

The steel for the forgings was forged, heat-treated and machined at U. S. Steel's Homestead Plant. Each forging measures 60¼″ long, 21¼″ wide at the base, 15⅝″ high and weighs about 2,450 pounds rough machined.

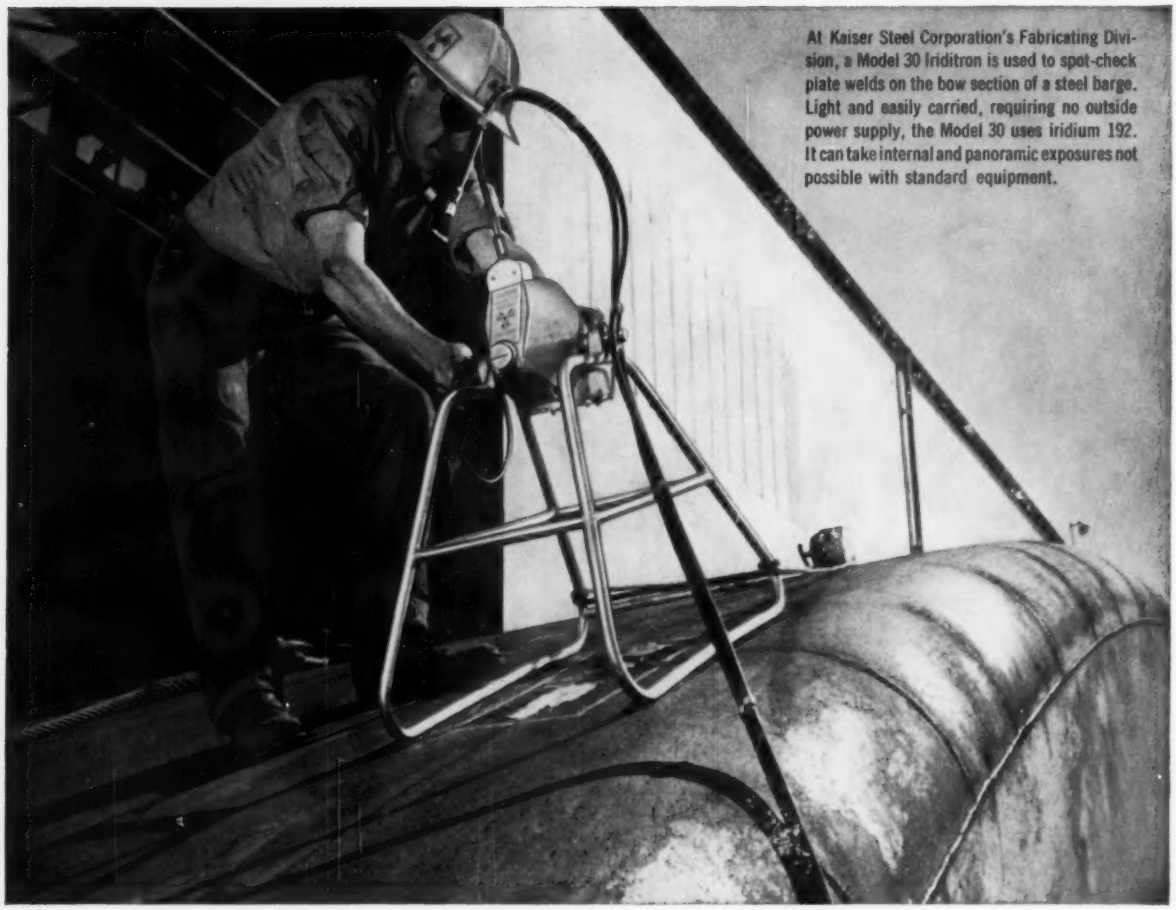
United States Steel makes many forgings for the nuclear industry. Here, a team of *experts* supervises and *controls every step* of forging production. This same team can handle your forging requirements. If you would like additional information about USS Quality Forgings, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

USS



At Kaiser Steel Corporation's Fabricating Division, a Model 30 Iriditron is used to spot-check plate welds on the bow section of a steel barge. Light and easily carried, requiring no outside power supply, the Model 30 uses iridium 192. It can take internal and panoramic exposures not possible with standard equipment.

Remote control of iridium...with Budd Iriditron units

- **Especially designed for remote handling of iridium 192**
- **Excellent for panoramic and internal exposure**
- **Permits exposure of iridium sources by remote control as far as 50 ft. away.**

Skid mounted or portable, this Budd Iriditron unit provides all the versatility of the traditional unshielded source for pipe weld radiography, panoramic exposure of multiple specimens, circumferential and longitudinal welds in boilers and pressure vessels. The unit can hold extremely strong sources . . . as much as 30 curies of iridium 192, approximately equivalent to a 260 KV X-Ray machine. This adds up to significant reductions in exposure times.

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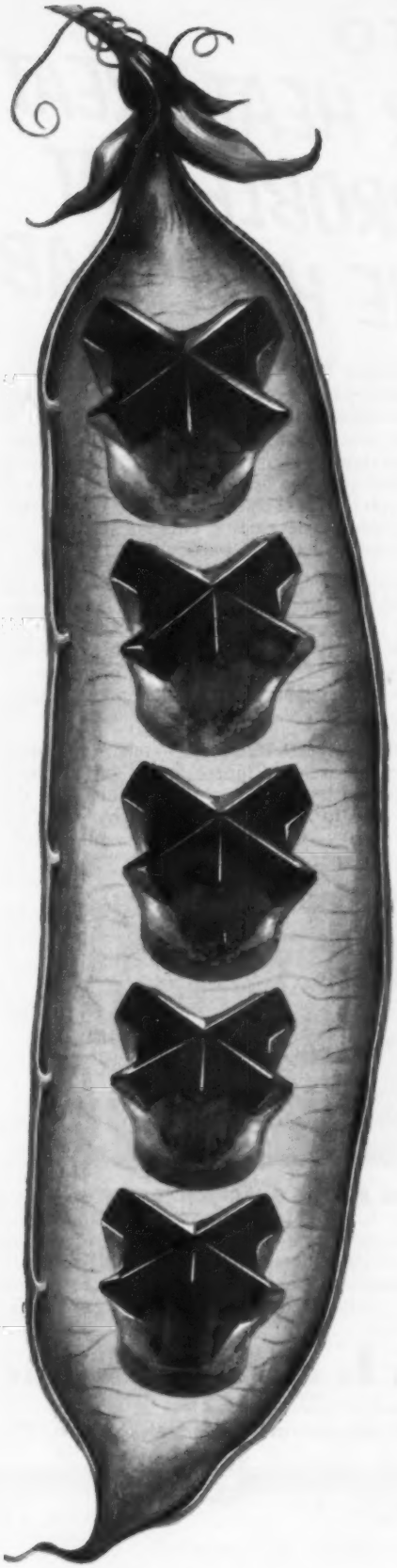
Circle 1250 on Page 48-B



No peas...

. . . can be more alike than your forged parts when you make them from Timken® steel forging bars. That's because of the uniform quality of Timken steel—uniformity in structure, chemistry and dimension. And that holds from heat to heat, bar to bar, order to order.

Even more advantageous for you, we handle orders individually. That way, we can target our procedures to *your* end-use requirements. You don't have to make costly interruptions in your operations for adjustment of equipment.

One big reason we can assure you such fine steel quality is our new Metallurgical Research Center. Here we use the most modern facilities—some unique in the industry—to study and analyze new steel compositions, solve customer problems.

When you buy Timken steel you get: *1) Quality that's uniform from heat to heat, bar to bar, order to order. 2) Service from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.*

For the greatest return from your modern forging operations, specify Timken steel forging bars. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®

***Fine Alloy* STEEL**

Circle 1161 on Page 48-B

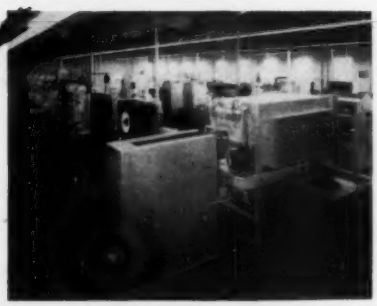
SEE THE ANSWER TO

YOUR HEAT TREAT PROBLEM AT THE HAYES LAB

Ever since 1918, C. I. Hayes has maintained a laboratory of the latest *production-line* furnaces and allied equipment (not lab models) on which actual heat treating processes can be duplicated and evaluated. Here you can take an active part in developing the heat treat procedure that will give you the exact results you need. You participate, too, in developing equipment that's coordinated to your own particular work.

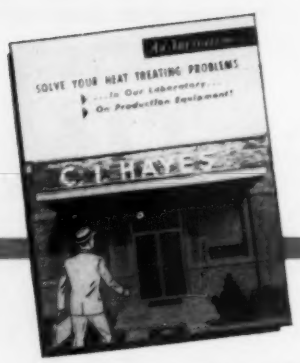
CUSTOMERS ARE WELCOME to make use of the lab without cost or obligation. Hayes equipment *plus* our engineering know-how *plus* the Hayes library of case histories—this combination is ready to help you solve your problems . . . either with standard furnaces, or special designs for special work.

HAYES SHOWED THE WAY—others followed. There are several "Chinese copies" of the Hayes lab in industry today . . . proof positive that the right way to solve heat treat problems is the Hayes way—by experimentation and demonstration—not by "sweet talk".



WANT RESULTS GUARANTEED? Take advantage of our lab—and its range of furnaces and atmosphere generators—whether you're hardening low carbon steel, sintering refractory metals, or brazing stainless. Let us show you how to improve your product, reduce costs, and speed production.

BULLETIN 1961 gives full lab details . . . write for your copy today.



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ELECTRIC CERTAIN CURTAIN FURNACES

Circle 1162 on Page 48-B

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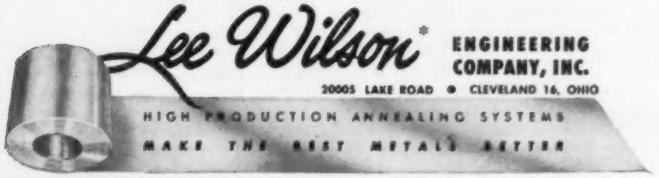
Steel magic is happening here! The smoke is blown through the air spaces between each lamination of the open coil—just as the gases are that now make the alloying and annealing of steels faster and easier—creating better steels at savings up to $40 a ton. We call it the Open Coil Process of Gas Alloying. We'll have complete data at our Booths 78 and 79 at the AISE Show, or you can get information immediately by contacting us direct.



* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES

Circle 1163 on Page 48-B

lished a 64-p. booklet "Heat Resistant Castings, Corrosion Resistant Castings—Their Engineering Properties and Applications."

947. Cemented Carbides

Booklet from *Carmet Div.* provides data on cemented carbides, including properties and design. These carbides can be cast, rolled, and forged and have 100 times the abrasion resistance of steel.

948. Alloy Castings

Duraloy Co. catalog describes facilities and cast products, including "HOM", a new high-temperature alloy for service up to 2200° F.

949. Graphite Products

National Carbon Co. produces graphite plate stock and machined guides used in aluminum extrusion operations. Information available on how these products speed production and assure a better end product.

950. High-Temperature Alloy

16-p. booklet discusses "Haynes Alloy 56", a lower-cost, high-temperature alloy with good strength and oxidation resistance in the 1200-2000° F. range. *Haynes Stellite Co.*

951. Refractory Concrete

Universal Atlas Cement has application and service data on "Lumnite" castable refractory cement for lining slow-cooling pits and furnaces.

952. Superalloy

"René 41" is vacuum-induction melted for higher strength and ductility. The alloy can be forged, welded, or formed. Details available from *General Electric.*

953. Refractory Metal Parts

Isostatic pressing and sintering of tungsten and molybdenum powders produces high strength parts for high-temperature—such as rocket nozzles. *Sylvania Electric Products* has the details.

954. Heat-Resistant Castings

Electro-Alloys Div. has published a brochure on "Supertherm", a heat resistant 26% Cr-35% Ni alloy for castings operating in the 1800-2300° F. range.

955. Ceramic Coating

Norton Co. has published a booklet on "Rokide" coating process which protects parts against abrasion and temperatures to 4600° F.

956. Fabricating Facilities

6-p. Catalog 30 discusses facilities and special fabrications produced at *Rolock Inc.*—process equipment, complex weldments, and pressure vessels of Inconel, Hastelloy and other alloys.

Tool Materials

962. Impact Forging

Information on *Chambersburg* "Impacter" for forging space-age metals up to 4500° F. Stock is struck from both sides. There is no shock, no vibration.

963. Ballizing Process

12-p. report on ballizing (pressing a precision ball through an unfinished hole) lists production and cost advantages, production setups, case histories, and product data. Range: 0.020 in. to 5 in. ID. *Industrial Tectonics, Inc.*

964. Press Control

Proximity "die-saver" switch will reduce scrap loss, die damage, and machine repairs caused by multiple heading. Bulletin 27B, a 32-p. instruction book from *Robotron Corp.*

965. Mist Coolant

"Spraymist" application methods for a variety of standard machining operations are illustrated and explained in 6-p. pamphlet from *Bijur Lubricating Corp.*

YES, we are geared to offer the "whole ball of wax" . . . the "complete crucible cycle" to our customers.

In the areas of design and engineering of vacuum crucibles our men have helped customers break through knotty technological problems posed by special vacuum applications.

In manufacturing or fabrication, know how gained through experience, has allowed us to cut costs while maintaining our recognized high quality.

And, in maintenance repair service we have not only saved our customers thousands of dollars but have delivered repaired crucibles with a **certification of test for pump down and leak rate** . . . ahead of schedule.

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SEND FOR DESCRIPTIVE LITERATURE:

BU-58 Button Furnace . . . CR-58 Crucible . . . FAC-58 Facilities Folder . . . IM-59 Ingot Molds . . . HT-59 Hot Topping Unit

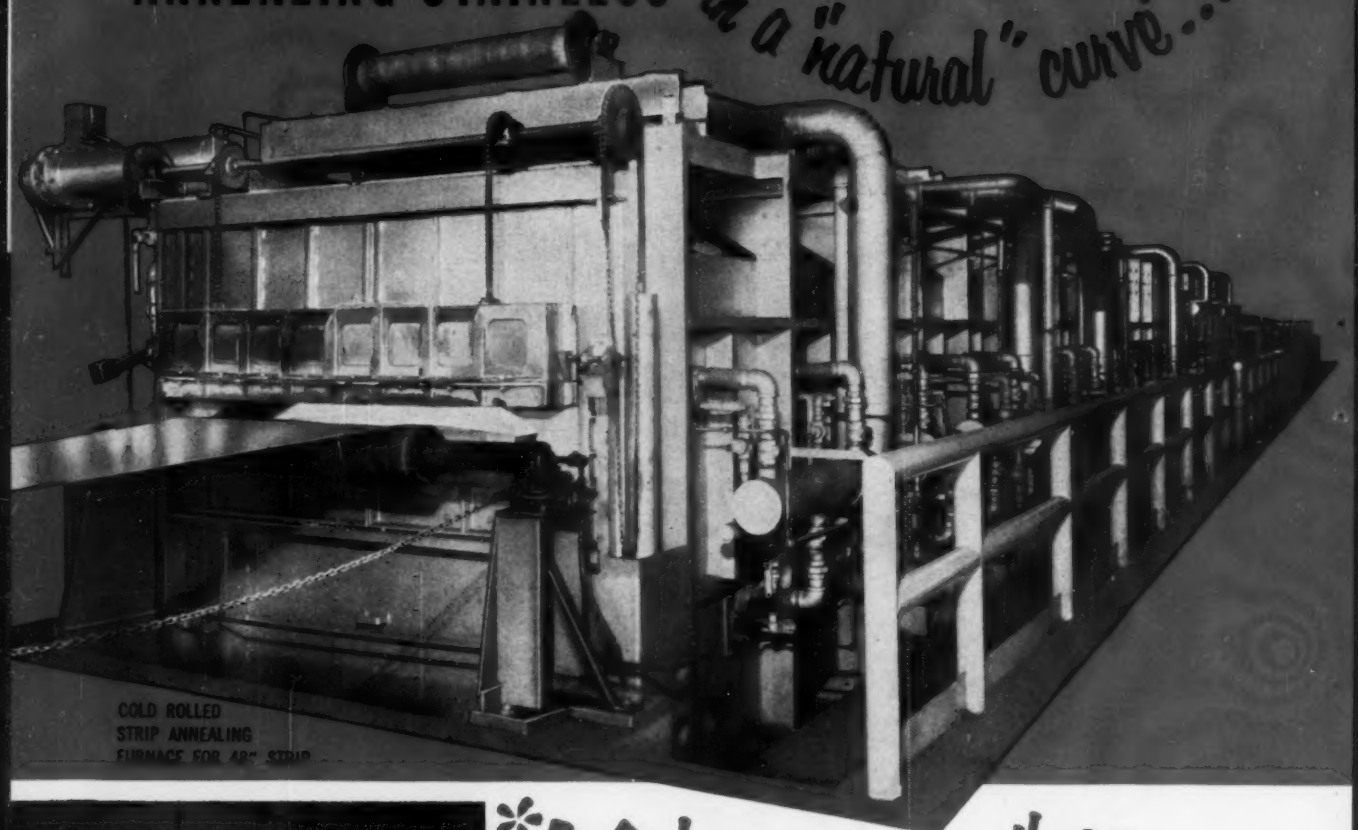
"Engineering Manufacturers for Industry"

ZAK MACHINE WORKS, INC.

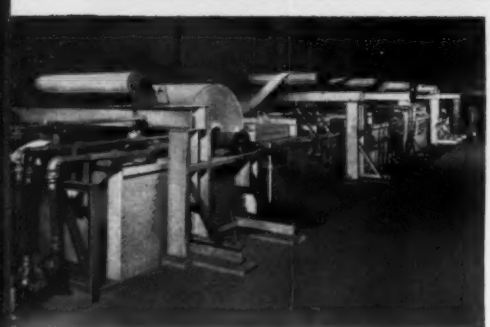
TROY (GREEN ISLAND) NEW YORK

Circle 1164 on Page 48-B

ANNEALING STAINLESS in a "natural" curve...



COLD ROLLED
STRIP ANNEALING
FURNACE FOR 48" STRIP



ABOVE: SALT DESCALING BATH. BELOW: HOT ROLLED STRIP LINE.

*A Catenary curve, that is...

...the natural path assumed by the strip as it passes through the continuous Annealing Furnace. Complete exposure of the strip surface to heat and furnace atmosphere and the uniform stress throughout the strip assure maximum product uniformity. Support of the strip by special soft compressed asbestos disc rolls located outside the ends of the furnace assures an unmarked surface.

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The support of the strip on special rolls and the proper application of thermal conditions are but part of the engineering technique and heat treating experience that enter into the design of Drever Stainless Strip Annealing and Descaling Lines. Keeping pace with the ever growing demand for heat treatment of stainless steel in all its forms has been a particular project at Drever. This specialization is reflected in the number of successful installations, in many sizes, now in operation.

DREVER ENGINEERING FOR YOU

The widening industrial and commercial use of stainless steel and the higher quality standards point up the need for producers to study the latest methods of heat treatment. Consult with our engineers regarding your requirements—or ask for Bulletin B-81. Drever Company, Bethayres, Pa. Phone: Wilson 7-3400.

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ENGINEERED TO YOUR PARTICULAR REQUIREMENTS

ENGINEERING AND MANUFACTURING FACILITIES AROUND THE WORLD THROUGH ASSOCIATES IN FRANCE, GREAT BRITAIN, GERMANY, ITALY AND JAPAN

Circle 1165 on Page 48-B

966. Toolsteel Guide

Written by Dr. B. L. Averbach of M.I.T., "Toolsteels", a basic guide to the use of tool and die steels has been published by *Climax Molybdenum Co.*

967. Drawing Oil

Flyer from *Baker-Gubbins Co.* on high-speed drawing oil, "No. 266-H", for copper tube reduction. Eliminates need for soap-dip tanks and allows bull-block speeds of 2000 fpm.

968. Precision Band Saw

Armstrong-Blum Mfg. Co. offers catalog on band saw with "Automatic-Accuracy" control—a servo-mechanism that senses and corrects drifting tendency of bandsaw blade.

969. Metallic-Base Lubricant

Bulletin 46 from *Swift* discusses "Flexi-met PCM", a tough, metallic-base lubricant with high heat stability. Fortified with additives including molydisulfide to provide E.P. properties.

970. Die Steel

Ziv Steel and Wire Co. offers publication on "Plancher" tool steel for applications involving shock loading, such as dies for punch presses.

971. Colloidal Graphite

Bulletin 426 from *Acheson Colloids Co.* on solving difficult lubrication problems encountered under conditions of extreme temperature, pressure, or abrasion.

Industrial Heating

973. Radiant Tubes

Advantages of light-walled fabricated tubes: (1) reduced furnace time and fuel, (2) uniform gas flow, (3) less carbon build-up and burn-out, and (4) up to 100% longer life. Bulletin from *Pressed Steel Co.*

974. Atmosphere Control

The *Electric Furnace Co.* offers good 12-p. booklet "Practical Aspects of Atmosphere Control" by R. J. Perrine, their Director of Research.

975. CO_2 Cooling

Nine advantages of extremely fast CO_2 cooling over mechanical cooling presented in Booklet CI from *Cardox Div.* Five other methods of reducing test chamber temperatures with CO_2 are diagrammed.

976. Vacuum Furnaces

Economical heat treating in a vacuum demands furnaces adapted to the material, size of part, and production requirements. These are discussed in Bulletins 5709 A and B by *C. I. Hayes.*

977. Salt Bath Furnace

Bulletin 151 presents information on salt bath furnaces for aluminum dip brazing, neutral hardening, high-speed steel hardening, annealing, billet heating, and solution treating of nonferrous metals. *Lindberg Engineering Co.*

978. Low-Temperature Cabinets

Folder from *Revco, Inc.* sets forth specifications on ultra low-temperature (to −140°F.) equipment for research, storage, testing, and production operations. Models available with thermal capacities up to 1300 Btu/hr. at 70°F.

979. Heat Treating Chart

Tempil Corp's four-color chart, "Basic Guide to Ferrous Metallurgy," illustrates forging, burning, annealing, transformation, stress-relieving, nitriding, blue brittle, normalizing, and carburizing ranges, as well as grain size changes vs. temperature.

980. Electric Furnace

For heat treating, drawing, annealing. Zone gradient control and input controllers are features. Range: 300 to 2300°F. without fan; 150 to 1875°F. with fan. *L & L Mfg. Co.*

981. Heating Elements

Bulletin H describes "Globar" silicon carbide electric heating elements for heat treating, forging, sintering, brazing, annealing, melting, roasting, and ceramic firing. The *Carborundum Co.* also produces thermistors, varistors, and resistors.

999. Environmental Testing

32-p. Brochure 100 from *Webber Mfg. Co.* presents data on environmental testing and other applications for controlled atmospheric conditions. Color chart summarizes latest data at altitudes from sea level to 2,000,000 ft.

1000. Combustion Equipment

8-p. catalog covers gas combustion and control equipment for industry, including burners, mixers, regulators, blowers, valves. Also size range, capacities, and applications for over 55 products. *Bryant Industrial Products Corp.*

1001. Infrared Sources

Technical Bulletin 59-220, 8 pages, discusses infrared source theories and laws; prediction of quantity and quality of radiation from heated sources; and other technical points. *Fostoria Corp.*

1002. Wire Cloth

130-p. reference manual on metal-mesh conveyor belts for continuous movement of products through heat treat ovens and other processes. *Cambridge Wire Cloth.*

1003. Vacuum Furnaces

Detailed information on vacuum-annealing and hardening furnaces with forced gas cooling for safe, economical testing of stainless and high-temperature alloys. *Ipsen Industries, Inc.*

1004. Radiant Tube Assemblies

General Alloys Co. has complete data on "Wrought-Cast" radiant tubes for consistent long life. A cast return bend is combined with straight tube made from rolled and welded plate.

1005. Induction Heating Units

Lepel High Frequency Laboratories will send catalog covering design and applications for high frequency induction heating units, including methods for heating non-conducting materials to high temperatures.

1011. Tube Furnaces

Details on carbon resistor-type tube furnaces for service to 5000°F. Both vertical and horizontal models are available with interlocking fail-safe features. *Pereny Equipment Co.*

1012. Metal Process Belts

Ashworth belts for continuous heat treating operations—such as brazing, hardening, quenching, annealing, and tempering—reduce handling and maintenance costs and boost production.

1013. Thermocouple Tubes

Bulletin 11-13 gives general application data, specifications, and ordering information on "Serv-Rite" protection tubes and wells made of iron, nickel, or other alloys. *Claud S. Gordon Co.*

1014. Heat Treating Salts

Eliminate scaling and decarburization in heat treating without special atmospheres. Technical data on "Aeroheat" salt baths and other metal chemicals from *American Cyanamid Co.*

1015. Furnace Systems

Information on furnace designs with mechanized loading and unloading plus instrumentation for automatic cycling, even for complex programs. *Despatch Oven Co.*

Circle appropriate number on Reply Card, p. 48B

The Most for Your "Rockwell Testing" Dollar!

Clark Hardness Testers are *guaranteed* accurate for all "Rockwell Testing". Clark's exacting workmanship in the production of penetrators, testing blocks, anvils, and other accessories pays off in exceptional accuracy on the job. No wonder the low cost surprises our first-time customers. *Clark Instrument, Inc., 10203 Ford Road, Dearborn, Mich.*

FREE REFERENCE BOOK

All information about hardness testing in easy-to-read text with many illustrations. Just write "Send Book" on your letterhead. Description and prices for Clark Hardness Tester and free Hardness Conversion Chart also available on request.

CLARK INSTRUMENT, INC.
10203 FORD ROAD
DEARBORN, MICHIGAN

Missile-Age Accuracy

Circle 1166 on Page 48-B

Laboratory facilities at Standard have kept well in step with the revolutionary advances which have been made in the field of metallurgy during the past decade. Plant facilities, too, are geared to produce even the most exotic of special alloys which today's industry demands.

And Standard's famed personalized service means that your most difficult problems can be resolved by our metallurgists and engineers and assures a finished product which meets your most exacting requirements, delivered in record time. Write today for the illustrated booklet, "Quality Control at Standard."

Standard Steel Works Division
BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

Circle 1167 on Page 48-B

1016. Protection Tubes

McDanel Refractory Porcelain Co. has data on high temperature atmosphere and vacuum muffle tubes, radiant furnace tubes, and pyrometer protection tubes. Diameters to 10 in.; temperatures to 3000°F.

1017. Electric Furnaces

Harrop Electric Furnace Div. manufactures standard and custom furnaces which are flexible and accurate in firing up to 2800°F. continuous operation.

1018. Melting Furnace

Information on Heroult electric furnace for efficient steel melting, available from *American Bridge Div.* The furnace is 100% mechanically operated.

1019. Heat Exchanger

Bulletin 120 and 132 on "Aero" heat exchanger for improving heat treating operations by controlling quench bath temperature. *Niagara Blower Co.*

1020. Motor-Generator

Heating machine components—control station, heat-quench station, motor-generator, fitted base—are combined into a custom-built "Inductron" Heating machine to meet exact requirements. Catalog M-2144. *Cincinnati Milling Machine.*

1021. Box Furnace

Bulletin 653 discusses *Hevi-Duty* travelling, double-end box furnace, which provides close (10°F.) control up to 1850°F. for bright tempering and stress-relieving stainless steel parts.

1022. Automatic Controls

"L & N" control instruments ("Electromox" temperature controllers and "Speedomox H" recorders) aid in producing a quality product economically. Data available from *Leeds & Northrup.*

1023. "Heat Treat Review"

Contains discussion of new developments in high-temperature gas carburizing, including heating curves, photomicrographs of test samples, and illustrations of carburizing equipment (Vol. 11, No. 2). *Surface Combustion Div.*

1024. Temperature Controls

Information on resistance bulb controller, which responds to temperature changes as small as 0.1°, available from *Honeywell.* Transistorized controller compensates for ambient temperature variations.

Cleaning and Finishing

1027. Salt Bath Descaling

Information on *Drever Co.* salt baths for continuous descaling of stainless strip. Equipment descales 18,700 lb. of cold reduced strip—52 in. wide and 0.018 to 0.095 in. thick—every hour.

1028. Vapor Degreasing

36-p. bulletin shows basic types of vapor degreasers and discusses cycles, operating procedures, stabilizers, causes of solvent contamination, and solvent recovery. *Hooker Chemical Corp.*

1029. Protective Coatings

Manual offered by *Allied Research Products, Inc.* on "Iridite," chromate conversion coatings and "Irilac," clear protective coatings, for aluminum, magnesium, and zinc parts.

1030. Aluminum Cleaners

Mitchell-Bradford Chemical Co. has issued three bulletins on *(a)* a non-etching cleaner for aluminum, (b) a combined cleaner and etcher and *(c)* a solution to remove smut from a cleaned and etched surface.

1031. Mechanical Deburring

4-p. folder details four methods of removing burrs and flash from parts: (1) airless blast cleaning, (2) barrel finishing, (3) vibrating, and (4) wet blast cleaning. *Wheelabrator Corp.*

1032. Compensating Device

The "Adjusta-Matic" is an electronic adjustment device which reduces grinding and buffing wheel wear and achieves a more uniform finish. *Packer Machine Co.*

1033. "Coatings Selector"

Released by *Bee Chemical Co.*—a guide to the selection of specialty coatings for application on metals, plastics, glass, or wood. Dip and flow coating as well as vacuum metallizing included.

1035. Metal Finishing Guide

4-p. guide contains information on materials for buffing, polishing, burring, satin finishing, buffing wheel set-ups, and wheel cements. There is also a section on additives and specialties for bright-plating with gold, silver, copper, nickel, cadmium, brass, and zinc. *Lea Mfg. Co.*

1036. Soak Cleaners

Frederick Gumm Chemical Co. offers Pamphlet 360 on "Clepo" soak cleaners, granulated or liquid. Application data and techniques included.

1037. Barrel-Finishing Compounds

4-p. Bulletin 901 contains specifications on all "Lorco" media and compounds for barrel and vibratory finishing. Various specialty media such as steel balls, wood, and "Jet forms" are covered. *Lord Chemical Corp.*

1038. Silicon Coatings

Bulletin 1570 from *Dampney Co.* contains information on line of silicone and silicone-ceramic heat-resistant coatings for protection to 1400°F. Available in aluminum and a full range of colors.

1039. Ultrasonic Cleaning

The "Autosonic" is an ultrasonic cleaner with a self-tuning feature that assures consistent peak performance cleaning regardless of load changes, solution level, liquid temperature, or solvent contamination. Bulletin 60-1, *Powertron Ultrasonics.*

1040. Glass Shot

Microbeads Inc. will send information and samples of "Glas-shot," microscopic glass beads for use with all types of wet or dry blast equipment.

1041. Copper Plating

Technical Data Files offered by *Allied Research Products, Inc.* on copper plating processes and auxiliary addition agents for increased anode corrosion and for better wetting action.

1042. Abrasive Shot

Data on "Malleabrasive" shot or grit which is tailor-made to meet individual cleaning conditions. *Globe Steel Abrasive.*

1043. Selective Plating

Brochure from *Sifco Meta-Chemical, Inc.* on "Dalic" selective plating of semiconductors and flexible circuits. No-flux soldering on aluminum and stainless is possible.

1044. Fluid Mixers

Make metalworking and cleaning more productive by using "Lightnin" mixers in quench tanks, for solvent dip cleaning, for mixing chemicals, and acid-rinse operations. *Mixing Equipment Co.*

1045. Clear Dip Coating

Bulletin M800 from *Bee Chemical Co.* on a water-soluble, water-thinnable and nonflammable dip coating for the protection of brass and brass-plated steel products. Product, process, and application data are given.

1046. Cleaner-Phosphatizer

Turco Products, Inc. has released Bulletin 108-26 on "Paintite," a combination cleaner-phosphatizer for iron, steel and

Circle appropriate number on Reply Card, p. 48B

PSC Sheet Alloy Radiant Tubes
COST LESS · LAST LONGER
Let Us Demonstrate This
If you are using cast alloy tubes, we can quote you substantially less on our all-sheet alloy tubes. And, with dies on hand for many commonly used sizes of return bends, we can frequently save our customers this important cost. Records of scores of installations show PSC "Thin Wall" tubes are giving much longer service life. For instance, Michigan Malleable Iron Co. reports: "We show an average life of over 3½ years for your fabricated tubes, which is about double our experience with cast alloy tubes". In PSC tubes the return bends are of the same metal and thickness as the legs, promoting uniform flow of gas and minimizing carbon build-up and consequent burn-out. Precision-assembled in any design or dimension. Also sheet-alloy heat-treating retorts and covers, boxes, baskets, fixtures, tubes, etc. We invite your inquiries.
Save with PSC All-Sheet Equipment
THE PRESSED STEEL CO. · Wilkes-Barre, Pa.
PSC
Circle 1168 on Page 48-B

Have a Metal Cleaning Problem

Detrex Engineers Have Been Coming Up With "Cost Saving" Answers for 30 Years

Every metal cleaning operation has its own particular problems—but they're seldom new to the Detrex engineer. With 30 years of experience, he can produce the right formula to insure maximum productivity and economy in your operation.

He will analyze your product, the type of soil to be removed, the proper equipment and cleaning agent needed, the space and manpower required—every factor that bears on the problem.

When he gives you his recommendation, you can depend upon it to make sense—and save dollars. And when you put his recommendation into practice, you can depend upon Detrex to follow through with the finest service in the business.

Depend on DETREX for Every Metal Cleaning and Processing Need

- PERM-A-CLOR NA (Trichlorethylene)
- Solvent Degreasers
- Ultrasonic Equipment
- Industrial Washer
- Phosphate Coating Compounds
- PAINTBOND Compounds
- Aluminum Treating Compounds
- Alkali and Emulsion Cleaners
- Rustproofing Materials
- Extrusion and Drawing Compounds
- Spray Booth Compounds

Write for your free copy of Dr. C. E. Kircher's informative paper: "Solvent Degreasing—What Every User Should Know"

DETREX CHEMICAL INDUSTRIES, INC.

Box 501, Dept. MP-960, Detroit 32, Michigan

World's Largest Exclusive Producer of Cleaning Chemicals and Equipment

zinc. Can be applied by immersion, spray washer, or steam cleaner.

1047. Descaling Salt

Descaling time on stainless steel tubes was cut from 90 min. (straight acid pickling) to 30 min. since switching to "Virgo" descaling salt. Literature on this and other metal cleaning operations from *Hooker Chemical Corp.*

Welding and Joining

1048. Brazing Furnaces

Pacific Scientific Co., maker of heat treating furnaces, has published a catalog on brazing applications and equipment.

1049. Hardsurfacing

Data sheet presents information on "Hardalloy 44," a low-hydrogen, consumable-type, coated electrode for hardsurfacing where severe abrasion and wear are encountered. Properties of deposited metal included. *McKay Co.*

1050. "Brazing News"

Contains application data on line of "Easy-Flo" silver brazing alloys for joining copper, brass, bronze, and other alloy parts. *Handy and Harman.*

1051. Hard-Surfaced Overlays

"Model D Spraywelder" is discussed in 4-p. leaflet from *Wall Colmonoy Corp.*... Applications, advantages of process, description of unit, procedures to use, powders available.

1052. Welding Design

Lincoln Electric Co. publishes a series of articles on "Weldesign"—ideas, guides, data, and nomographs for efficient welding design. Folder 1204.1 features "Design of Welded Rolls."

1053. Brazing Manual

24-p. manual contains data on brazing shapes, castings, tubing, and assemblies made of aluminum, cast iron, copper, brass, and steel. *All-State Welding Alloys Co., Inc.*

1054. Arc Welding Equipment

6-p. folder from *Hobart Brothers Co.* illustrates line of automatic and semiautomatic arc welding equipment. Applications for the various processes included.

1055. Brazing Alloys

Bulletin 20 from *Handy & Harman* describes silver brazing and its advantages. Missile assemblies are being induction brazed with "Easy-Flo 45."

1056. Brazing Furnaces

Harper Electric Furnace Corp. has detailed information on industrial furnaces for brazing, sintering, and annealing. Furnace types: box, pusher, mesh belt hump or straight-through, roller hearth, bell, elevator, or pit.

1057. Filler Wire

Armetco, Inc. has folder on vacuum-induction-melted filler wire for improved quality in the weld deposit via low gas content and reduced inclusions.

Inspection and Control

1058. Testing Machine

Bulletin RF-10-59 concerns "Riehle-Los" machine for imposing fluctuating axial loads at 5 to 1000 cycles per min. Capacities range from 12,000 to 300,000 lb. *Riehle Testing Machines.*

1059. Biplane Diffractometer

The "Series 3488" is a goniometer arranged for structure analysis with a wide range of diffraction techniques and for use in spectrochemical analysis. Bulletin from *Picker X-Ray Corp.*

1060. Universal Testing Machines

Bulletin 47 gives complete information about "Super-L" machines, with instantaneous load indication and dependable hydraulic loading with precision control. *Tinius Olsen.*

1061. Laboratory Shakers

Burrell Corp. offers Bulletin 307 on laboratory shakers. Gentle to violent action. Side clamps take bottles and Erlenmeyer flasks. Loads need not be balanced.

1062. Magnifying Comparator

Folder reports on a magnifying comparator for the measurement and comparison of miniature parts and assemblies. includes five new reticles (transparent scales) added to the 15 already available. Subdivisions to 0.002 in. *Fine-Scale Co.*

1063. Ultrasonic Testing

Branson Instruments, Inc., offers 8-p. Bulletin T200 which covers operation, technique, and specifications for the "Sonoray 5" flaw detector. Application of contact, immersion, and water column testing methods discussed.

1064. Metallograph

American Optical Co. offers complete information on the "workhorse" metallograph and accessories. A Polaroid Land Camera gives prints in 60 sec.

1065. Mass Spectrometer

Consolidated Electrodynamic Corp. offers 6-p. pamphlet on "Type 21-130" mass spectrometer for laboratory analyses. This is a medium-priced machine which approximates the performance of larger ones in mass range: 2 to 230.

1066. Extensometer

Brochure 522 illustrates single-piece adjustable extensometer, which takes rectangular or round specimens up to a ½ in. maximum dimension. *Testing Machines, Inc.*

1067. Metallurgical Services

Literature can be obtained from *Charles C. Kawin Co.* outlining the metallurgical services available—metallographic examination, chemical analysis, physical and mechanical testing, and metrology.

1068. Recorder-Controller

Catalog 08-101-A from *Weston Instruments Div.* gives complete information on "Weston" instruments for industry, including circular chart recorders which provide needed versatility for effective process control.

1069. Research Facilities

Booklet from *Ernest F. Fullam, Inc.* describes research and development facilities available to small companies for improving their products, reducing operating costs, or developing new products.

1070. Strain Measurement

Strain Gage Catalog has been issued by *Baldwin-Lima-Hamilton* covering properties, applications and test procedures and instrumentation for "SR-4" gages.

1071. Superficial Hardness

Catalog RT-58 gives complete information on line of Rockwell hardness testers as well as a superficial tester for making shallow measurements. Penetrations of less than 0.005 in. are made rapidly, accurately and easily. *Wilson Mechanical Instrument Div.*

1072. Tensile Tester

Information on bench-mounted tensile and compression tester which is motorized, easy to operate, and comes in capacities from 1000 to 20,000 lb. *Steel City Testing Machines.*

1073. Gamma Radiography

"Multitron" and "Iriditron" units for

Circle appropriate number on Reply Card, p. 48B

300% FASTER ULTRASONIC CLEANING*

with **SELF-TUNING**

Self-tuning Autosonic cleaners by Powertron clean faster, better and cheaper because they: Eliminate operator training and monitoring; Release labor for other work; Reduce rejects; Save on solvents.

HERE'S HOW IT'S DONE

The Autosonic is electronically self-tuned by its exclusive feedback transducer and requires no tuning knobs or meters. A simple switch is the only control.

Only Autosonic cleaners give you consistent peak performance cleaning regardless of load, solution level or temperature, contamination or operator inattention.

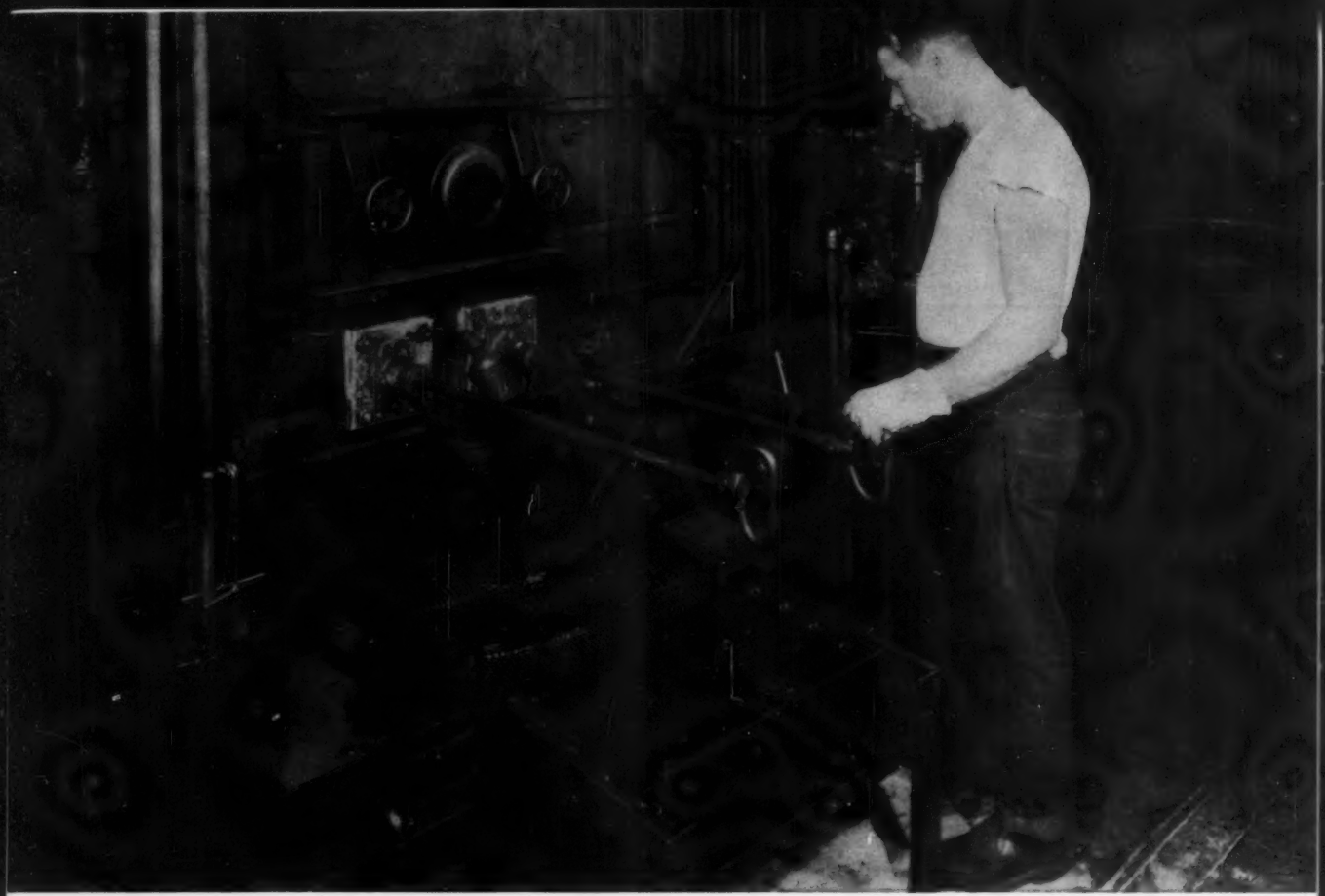
Powertron's complete line of Autosonic generators, tanks, cabinet models, degreasers and immersible transducers is immediately available from stock. Ask for free demonstration by Sales Engineer.

*Case Histories on File.

WRITE FOR FREE BULLETIN 60-1 "HOW TO CLEAN ULTRASONICALLY WITH SELF TUNING"

POWERTRON ULTRASONICS CORP.
DEPT. MP-9
PATTERSON PLACE • ROOSEVELT FIELD
GARDEN CITY, L.I., NEW YORK • PIONEER 1-3220

Circle 1170 on Page 48-B



National Cash Register reports:

"Gulf Super-Quench eliminates costly straightening"

Frank G. Wymer, right, Job Foreman, Heat Treat Department, and R. H. Ball, Gulf Sales Engineer, discuss physical properties and tolerances required for National Cash Register's accounting machine parts.

"We produce 25,000 to 30,000 separate parts for our cash registers, accounting machines and computers," says C. E. Mentel, Heat Treat Foreman, National Cash Register Company, Dayton, Ohio. "All are thin-sectioned parts which must be hardened uniformly to accurate dimensions. With so many different parts to be quenched, naturally distortion must be closely controlled to avoid costly straightening."

Fortunately, distortion is not a problem at National Cash Register, and costly straightening operations after quenching are unnecessary. For 20 years NCR has built its entire heat treating program around dual action Gulf Super-Quench. "Gulf Super-Quench," says Mr. Mentel, "lets us get the hardness we need with negligible distortion. It keeps growth within predictable limits, and within quenched tolerances as low as plus .001-in., minus .000-in."

Gulf Super-Quench combines superior quenching power through the hardening range with slow cooling in the final or distortion ranges. More than likely, this quenching oil can be used profitably in your heat treat department. Write us today for comprehensive literature on Gulf Super-Quench. Or, just contact a Gulf Sales Engineer at your nearest Gulf office.

GULF OIL CORPORATION
Dept. DM, Gulf Building, Pittsburgh 30, Pa.

GULF MAKES THINGS RUN BETTER!

Circle 1171 on Page 49-B

GULF

gamma radiography have hermetically sealed sources under positive control at all times and a fail-safe mechanism which returns source to shielded head if power fails. *Budd Instruments Div.*

1074. Brinell Testing Machines

Detroit Testing Machine Co. has brochure on "HB" series laboratory tester and direct-reading "DH-1" tester for production-line inspection.

1075. High-Speed Testing

Instron Engineering Corp. presents data on dynamic digital system for materials testing at high speed without the need for chart evaluation.

1076. Metallographic Equipment

For routine work or advanced research, *Bausch and Lomb* metallographs help boost output and maintain quality. Catalog E232 shows how you can save on time and materials.

1077. Recording pH Meter

A continuous record of pH changes is now possible in low-priced meter from *Analytical Measurements, Inc.* Illustrated Brochure 3R presents complete specifications.

1078. X-Ray Unit

Picker X-Ray Corp. manufactures a "Series 6181" constant potential X-Ray diffraction unit with built-in controls and stabilizers to insure accurate and repeatable operation. Details available.

1079. Testing Machines

Riehle Testing Machines has information on universal, creep, stress-rupture, fatigue, impact, Brinell, torsion, and Rockwell hardness testing machines.

Production and Casting

1080. Industrial Blowers

Catalog 126B contains complete specifications on blowers. Available in standard capacities of ½ to 1000 hp.; up to 20,000 cfm.; and 4 oz. to 10 lb. pressure. *Spencer Turbine Co.*

1081. Melting Equipment

Information from *Zak Machine Works, Inc.* on vacuum furnaces and crucibles, hot topping units, skull molds, and ingot molds, for production and research applications.

1082. Furnace Insulation

12-p. design and data brochure from *Johns-Manville* on "Superex" insulation of diatomaceous silica and asbestos. Easy to cut and bundle, it weighs only 2 lb. per sq. ft. per inch of thickness.

1083. Vacuum Furnaces

Kinney Mfg. Div. offers Bulletin 4510 on vacuum furnaces including equipment for melting and casting billets weighing up to 50 lb. Melt additions can be made without breaking seal.

1084. Shell Cores and Molds

Aurora Metal Co. announces a brochure on "Faskure" resin-coated sand for producing shell cores and molds. Various mixes available and typical applications included.

1085. Vacuum Pumps

"Series H Microvac" pumps are exceptionally compact and are designed to give years of vibration-free service. *F. J. Stokes Corp.* offers data on vacuum pump applications as well as a handy vacuum slide-calculator.

1086. Diffusion Pumps

Consolidated Vacuum Corp. has issued Bulletin 6-100 on high speed diffusion pumps. Operating range is 2×10^{-7} to 1×10^{-3} mm. Hg. Throughput cost is about half that of conventional pumps.

1087. Gas Producers

4-p. Bulletin GED-3996 on "Neutralene" gas producers, which provide a low-cost "neutral" atmosphere to prevent oxidation and decarburization during annealing, normalizing, brazing, hardening, and sintering. *General Electric Co.*

1088. Automatic Sampler

Pamphlet 47A from *Hardinge Co.* gives information on automatic sampler (for wet and dry processes) which takes "cuts" from a stream of moving material in a continuous-flow process.

Parts, Forms, Shapes

1096. Steel Parts

"Tool Steel Process" (TSP) hardened products are used as component parts on soaking pit and ladle cranes, mills, and ingot buggies. Gears, pinions, track and sheave wheels, leveller and pinch rolls, sprockets, and shafts are made by *Tool Steel Gear & Pinion Co.*

1097. Tubing Selection Guide

Joseph T. Ryerson & Son, Inc. has published a guide for selecting tubing according to type, finish, analysis, formability, machinability, weldability,and relative cost. Comparisons are made between seamless and welded round, square, and rectangular tubing for mechanical, hydraulic, and structural applications.

1098. Heat Treatable Tubing

Data Memorandum No. 19 describes "Ni-Span C," a precipitation hardenable alloy with a constant modulus of elasticity from −50 to +150° F. Available from *Superior Tube Co.* as tubing in seamless and "Weldrawn" grades, in a wide range of sizes, shapes, and wall thicknesses.

1099. Steel Pipe

Bulletin TT942 "Fittings and Flanges for Lightweight Pipe" available from *Tube Turns Div.* Savings include: lower cost than standard weight, lower shipping and handling costs, and increased flow efficiency.

1100. Shaped Wire

16-p. Catalog DH-1226-A from *Page Steel and Wire Div.* covers facilities for producing ovals, triangles, half-rounds, keystones, and other shaped wire. Also contains data on properties of steel wire, standard wire gages, and hardness conversion tables.

1101. Contour Rolled Stock

Literature describes contour rolled stock parts for machinery, appliances, engines, and fittings. Any cold-workable material can be precision formed, including brass, stainless, Monel, and Inconel. *D. E. Makepeace Div.*

1102. Steel Tubing

Bulletin T459 from *Babcock & Wilcox Co.* covers characteristics of "Lectrosonic" steel cylinder tubing, including guaranteed maximum micro-inch finish on I.D.

1103. Steel Forgings

National Forge Co. gives the facts on tough forging jobs in their Bulletin NH-1058. Facilities include basic electric melting shop and a modern nitriding installation.

1104. Metal Powders

Data sheets offered by *Vanadium-Alloys Steel Co.* on "Vasco" prealloyed stainless steel powders for improved molding and pressing qualities and higher strength and ductility.

1105. Fine Wire

Riverside Alloy Metal Div. offers wire with diameters as fine as 0.0025 in. in the following alloys: stainless, Monel, Duranickel, Inconel, Incoloy, Perma-nickel, phosphor bronze, nickel silver, cupronickel, and carbon steel.

Circle appropriate number on Reply Card, p. 48B

SELECTIVE PLATING

Production and Repair Plating

without using immersion tanks

Enables You to (1) Precision-plate selected areas economically — without disassembling components; (2) Deposit metals rapidly where conventional electro-plating is impossible or difficult. Mobile equipment takes the process to the job.

Write for Descriptive Brochure.

SIFCO METACHEMICAL, INC.

935 East 63 Street • Cleveland 3, Ohio

A Subsidiary of The Steel Improvement & Forge Co.

AGENTS

MARLANE DEVELOPMENT CO., INC. 153 East 26th Street New York 10, N.Y.

PIDDINGTON & ASSOCIATES LTD. 3219 East Foothill Blvd. Pasadena, California

OHIO METACHEMICAL, INC. 2742 Second Street Cuyahoga Falls, Ohio

D & S AVIATION CO., LTD. 671 Laurentides Blvd. Pont Viau, Montreal, Quebec

Circle 1172 on Page 48-B

Wyman-Gordon makes a major
Now parts are being forged in

Nickel-base
high-temperature alloy
45" diameter
520 pounds

BROAD RANGE OF GAS TURBINE COMPONENTS ALSO BEING PRODUCED IN:

- Low-Alloy, High-Strength Steels
- Intermediate-Temperature Alloys
- Titanium and Refractory Metals
- Aluminum and Magnesium

High-strength steel
19" diameter
143 pounds

PHYSICAL PROPERTIES

	ALLOY*	TEST TEMPERATURE °F.	HEAT TREAT	GUARANTEED MINIMUM ULTIMATE TENSILE STRENGTH PSI	GUARANTEED MINIMUM 0.2% YIELD STRENGTH PSI	GUARANTEED MINIMUM ELONGATION %	TYPICAL VALUES ULTIMATE TENSILE STRENGTH PSI	TYPICAL VALUES 0.2% YIELD STRENGTH PSI	TYPICAL VALUES ELONGATION %
TENSILE AND YIELD STRENGTHS	Waspaloy	RT	A	175,000	120,000	15.0	194,000	136,000	24.0
		1000	A	162,000	112,000	13.0	175,000	124,000	23.0
	René 41	RT	B	180,000	132,000	12.0	200,000	150,000	15.0
		1400	B	135,000	115,000	13.0	145,000	125,000	18.0
	Astroloy	RT	C	190,000	138,000	10.0	205,000	152,000	12.0
		1400	C	150,000	122,000	12.0	160,000	132,000	15.0
	U-500	RT	D	175,000	120,000	10.0	195,000	135,000	12.0
		1400	D	125,000	105,000	12.0	140,000	120,000	15.0
	M-252	RT	B	170,000	115,000	15.0	185,000	125,000	20.0
		1000	B	160,000	105,000	15.0	165,000	115,000	22.0

	ALLOY*	TEMPERATURE STRESS	GUARANTEED MINIMUM	TYPICAL VALUES
STRESS RUPTURE	Waspaloy	1350°F.—70,000 psi	70 hours—6% Elongation	130 hours—16% Elongation
	René 41	1350°F.—85,000 psi	30 hours—8% Elongation	60 hours—15% Elongation
	Astroloy	1800°F.—20,000 psi	20 hours—7% Elongation	35 hours—12% Elongation
	Udimet 500	1650°F.—25,000 psi	30 hours—6% Elongation	55 hours—12% Elongation
	M-252	1500°F.—40,000 psi	30 hours—8% Elongation	55 hours—16% Elongation

NOTE: The guaranteed minimums are based upon radial and tangential test locations.

COMPOSITION AND HEAT TREATMENT

	ALLOY*	ELEMENTS C	Cr	Mo	Co	Ti	Al	B	Ni
CHEMISTRY	Waspaloy	.08	19.0	4.3	13.5	3.0	1.4	.004	Balance
	René 41	.08	19.0	10.0	11.0	3.1	1.6	.004	Balance
	Astroloy	.05	15.0	5.0	15.0	3.5	4.3	.030	Balance
	Udimet 500	.07	18.5	5.0	18.3	3.0	3.0	.003	Balance
	M-252	.15	20.0	10.0	10.0	3.0	1.3	.002	Balance

HEAT TREATMENT	A.	1850°F.—4 hours—OQ; 1550°F.—2 hours—AC; 1400°F.—16 hours—AC
	B.	1950°F.—4 hours—AC; 1400°F.—16 hours—AC
	C.	2100°F.—½ hour—AC; 1400°F.—16 hours—AC
	D.	1975°F.—4 hours—AC; 1500°F.—24 hours—AC; 1400°F.—16 hours—AC

NOTE: Refer to appropriate heat treat code in Tensile & Yield Strength table.

*Waspaloy: Pratt & Whitney Aircraft Corp.; René 41, Astroloy and M-252: General Electric Company; Udimet 500: Metals Division, Kelsey-Hayes Company.

contribution to gas turbine progress . . . these new Superalloys with Guaranteed Minimum Properties

permits designing to higher operating stresses . . . increased efficiency . . . greater component reliability for every gas turbine application

Rapid progress in developing the gas turbine has materially extended application of this prime power source to areas other than aircraft. Significant contributions in forging techniques and metallurgical advancements by Wyman-Gordon have in part made this possible.

Now designers are free to explore new frontiers of turbine performance unhampered by former material limitations. The high temperature alloys shown here exhibit outstanding tensile and stress rupture strengths in elevated temperature environments. These alloys have been forged into discs, shafts, rings, blades and vanes on a production scale.

Wyman-Gordon offers these alloys to *guaranteed minimum properties* for such vital components. This is made possible by the broad experience in forging parts from all difficult-to-work materials, including a complete range of low-alloy, high-strength steels; intermediate-temperature alloys; light metals; titanium and the refractory materials.

Our metallurgists and forging engineers are prepared to counsel on turbine components . . . evaluating material requirements and forging of existing designs and development parts. For assistance or additional information on Superalloy forgings, write—Product Manager, Turbine Applications, Wyman-Gordon Company, Worcester, Massachusetts.

WASPALOY

•

RENÉ 41

•

ASTROLOY

•

UDIMET 500

•

M-252

MEETING DESIGNERS' NEEDS IN EVERY TURBINE APPLICATION

- Aircraft and Missile
- Nuclear Power and Propulsion
- Rail and Highway Transport
- Power Generation
- Air Supply and Pumping
- Pipeline Boosting
- Auxiliary Service
- Automotive
- Marine Propulsion
- Stationary Power

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

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Circle 1173 on Page 48-B

Ammonia from Armour is

PURE!

Armour Anhydrous Ammonia has a guaranteed minimum purity of 99.98%. Ammonia so pure, you have no problems with moisture, oil or non-condensable gases.

You are always assured of excellent heat treating results, because Armour quality standards are based on an extra control test made when the ammonia is ready for shipment to you. *Every* cylinder and tank truck of Armour Ammonia is subjected to a rigid qualitative test after filling to make sure it is *at least* 99.98% pure *when delivered* to you. This extra Armour test eliminates the danger of your receiving ammonia that has been contaminated during the filling process.

Armour Ammonia is also backed by the finest technical service available. Armour's Technical Service Department will furnish blue-prints and engineering recommendations . . . supervise your cylinder and storage tank installations and give additional aid whenever you need it, at *no extra cost.*

Ammonia Sales

Armour Industrial Chemical Company

Division of Armour and Company
110 North Wacker Drive • Chicago 6, Illinois

Circle 1174 on Page 48-B

The American Society for Metals and Metal Progress serve 32,000 member-readers in 11 major areas of the metals industry.

The ASM is the communications center for technical information wherever metals are produced, processed, fabricated, designed, tested and applied. Metal Progress, monthly engineering magazine of the Society, reports on engineering developments in these 11 major technological areas:

FERROUS METALS: Alloy, Carbon, Free Machining, Stainless Steels, Hot and Cold Finished Bars.

NONFERROUS METALS: Aluminum, Beryllium, Brass, Bronze, Columbium, Copper, Lead, Magnesium, Molybdenum, Monel, Nickel, Rare Earths, Tantalum, Titanium, Tungsten, Zinc, Zirconium.

HEAT- AND CORROSION-RESISTANT AND ELECTRICAL MATERIALS: Special Alloys; Carbon, Graphite; Ceramics, Cermets, Thermal Insulating and Special Electrical Materials.

RADIATION AND NUCLEAR MATERIALS & EQUIPMENT: Metallic and Non Metallic Reactor Materials, Fuel Elements, Pressure Vessels, Control Elements, Related Equipment.

TOOL MATERIALS, CUTTING AND FORMING EQUIPMENT: Abrasives; Carbides; Coolants, Oils and Lubricants; Arc and Gas Cutting Equipment, Saws; Forging, Pressing, Extruding, Chemical Milling, Slitting, Straightening, Spinning and Explosive Forming Equipment; Tool and Die Steels, Plastic and Other Short-Run Die Materials.

INDUSTRIAL HEATING EQUIPMENT AND SUPPLIES: Atmosphere Generators and Gases; Commercial Services; Furnaces; Controls, Indicators and Recorders; Induction, Flame and Salt Bath Equipment; Ovens; Cryogenic Equipment; Pyrometers; Quenches; Samplers and Analyzers; Trays, Refractory Parts.

CLEANING AND FINISHING EQUIPMENT AND SUPPLIES: Alkaline Cleaning, Pickling, Degreasing, Descaling, Buffing, Polishing, Blasting, Plating; Porcelain Enameling, Purifying; Painting Equipment and Supplies; Rust Preventives; Abrasives.

WELDING AND JOINING EQUIPMENT AND SUPPLIES: Gas, Resistance and Arc Welding Equipment and Supplies; Electrodes; Adhesives, Fasteners; Hard Surfacing, Brazing and Soldering Equipment and Supplies.

INSPECTION AND CONTROL EQUIPMENT AND SUPPLIES: Microscopes and Attachments; Analytical and Mechanical Equipment; Gages, Comparators, Hardness Testers, Nondestructive, Electronic and Other Scientific Inspection Equipment.

PRODUCTION AND CASTING EQUIPMENT AND SUPPLIES: Electric and Vacuum Furnaces and Equipment; Refractories; Ferro Alloys; Foundry Irons and Coke; Rare Earths; Alloying and Refining Agents; Annealing, Soaking and Sintering Furnaces; Rolling Equipment; Industrial Gases; Foundry Equipment and Supplies.

PARTS, FORMS AND SHAPES FOR DESIGN AND APPLICATIONS: Castings (Malleable, Gray Iron, Steel, Nonferrous), Forgings, Extrusions, Powder Metal Parts, Springs, Stampings, Tubing, Weldments, Wire.

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Please Include Your Name and Address!

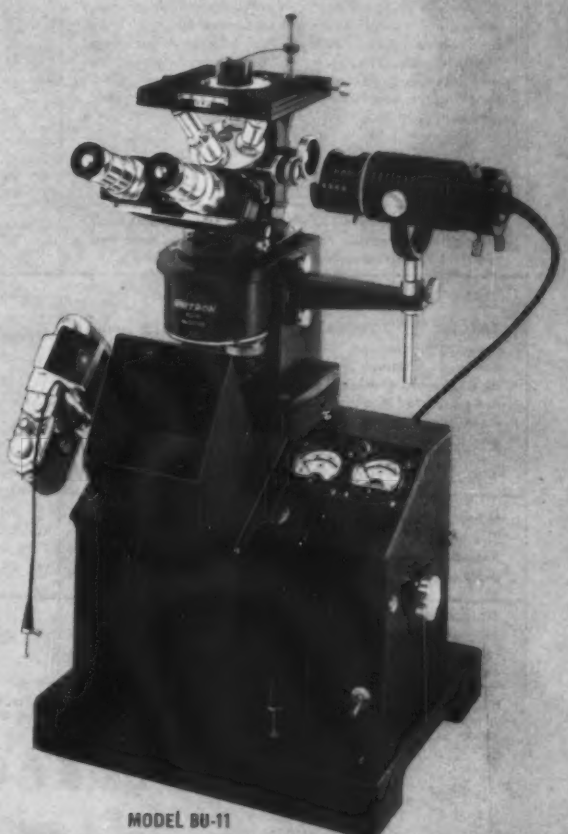
These typical 25 took a total of 152

HERE ARE 25 DISCRIMINATING BUYERS WHOSE OVER 152 ORDERS AND REORDERS PROVE COMPLETE SATISFACTION WITH THESE TWO UNITRON INSTRUMENTS. AMERICAN BRASS, BATTELLE MEMORIAL INSTITUTE, CARNEGIE INSTITUTE, DOW CHEMICAL, E. I. DUPONT, GENERAL ELECTRIC, GENERAL MOTORS, GOODYEAR ATOMIC, I. B. M., MINNEAPOLIS HONEYWELL, M. I. T., MISSOURI SCHOOL OF MINES, MOTOROLA, NATIONAL BUREAU OF STANDARDS, NATIONAL CASH REGISTER, R.C.A., REYNOLDS METALS, UNION CARBIDE & CARBON, UNIV. OF COLORADO, UNIV. OF CINCINNATI, UNIV. OF WASHINGTON, UNIV. OF WISCONSIN, U.S. GOVERNMENT, U.S. STEEL, WESTINGHOUSE ELECTRIC.

MODEL MEC

UNITRON INVERTED Metallurgical Microscope: This compact unit provides many of the features usually found only in larger metallographs. Standard equipment includes optics for 25–1500X, polarizers, filters, transformer in base, etc. A built-in camera attachment for 35mm. photography is included with the binocular and available for the monocular model. Extra accessories include Polaroid camera attachment, vacuum heating stage and illuminator for transmitted light. Think of the time which your laboratory can save by providing each metallurgist with one of these handy, inexpensive units for use at his desk.

Monocular Model MEC $399 Binocular Model BMEC $615



MODEL BU-11

UNITRON METALLOGRAPH and Universal Camera Microscope: A completely self-contained instrument of modern design for visual observation, photography, projection, and measurement of both opaque and transparent specimens; using bright field, dark field, or polarized illumination. Standard equipment includes all optics for 25–2000X, polarizers, filters, 3¼" x 4¼" camera, and many accessories. Also available are camera attachments for Polaroid, 35mm., and motion picture photography; vacuum heating stage for temperatures to 1500° C.; and macro-objectives (5–40X). Even laboratories on a limited budget can enjoy the precision, speed and efficiency possible only with a complete installation of this type.

Monocular Model U-11 $1195 Binocular Model BU-11 $1379

There is a free 10 day trial offer on any UNITRON Microscope.

Let the instrument prove its value to you —in your own laboratory—before you decide to purchase.

See for yourself why . . .

THE TREND IS TO UNITRON

Circle 1108 on Page 48-B

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UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.

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Please rush UNITRON'S Microscope Catalog 2-G

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THESE 13 SPECIAL ALLOYS FROM *can help you solve design problems . . .*

As the result of the knowledge gained over the years by working closely with hundreds of customers in helping solve innumerable design and production problems, the Mueller Brass Co. has developed a series of special alloys for use in tough or unusual applications.

This group of special alloys, each having distinct characteristics and advantages, are available in rod form in many sizes and shapes as well as forgings.

CHARACTERISTICS AND APPLICATIONS	ALLOY NO.	NAME	TEMPER
TUF-STUF® ALUMINUM BRONZES AND NICKEL ALUMINUM BRONZES have great strength characteristics. All are more resistant to corrosion cracking under load than copper-zinc alloys and, in addition, some are heat-treatable. They can withstand heavy pounding and have proved excellent for such parts as gibs, cams, valve seat inserts, shifting forks and propeller hub cones.	224E-30	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 165
	224E-75	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 175
	224C	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 185
	224H	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 200
	224K	"Tuf-Stuf" Nickel Aluminum Bronze	BRINELL 3000 KG load 250
ALUMINUM SILICON BRONZE is free turning; has high strength, is corrosion resistant and non-magnetic and resistant to corrosion cracking under load.	802	Aluminum Silicon Bronze	ROCKWELL-B 75
600 SERIES® FORGEABLE BEARING ALLOYS range from high strength to low loaded ductile. All are corrosion resistant, free cutting, can be used with hard or soft mating members and can be soldered. They are employed in a great variety of applications ranging from pump gears and valve stems to pinion shafts and transmission rings.	600	Forgeable Bearing Alloy	ROCKWELL-B 88
	601	Forgeable Bearing Alloy	ROCKWELL-B 87
	602	Leaded Forgeable Bearing Alloy	ROCKWELL-B 87
	604	High Leaded Forgeable Bearing Alloy	ROCKWELL-B 86
	605	Low Leaded Forgeable Bearing Alloy	ROCKWELL-B 80
MANGANESE BRONZE ALLOYS are exceptionally strong, tough, resistant to shock and corrosion. Good for screw machine products and forgings for aircraft parts.	241A	Manganese Bronze A	ROCKWELL-B 85
	721	Manganese Bronze High Tensile Grade B	BRINELL 1000 KG load 200
TELLURIUM COPPER has very high electrical and thermal conductivity combined with good corrosion resistance and machinability. Excellent for electronic components.	799	Tellurium Copper	ROCKWELL-B 45

NOTE: The values shown are average values normally obtained in production. Variations must be expected in practice. The values should be used as a general guide rather than the basis for specifications.

ONE DEPENDABLE SOURCE FOR

COLD-PREST® IMPACT EXTRUSIONS

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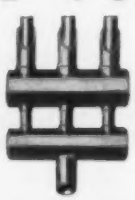

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MUELLER BRASS CO.

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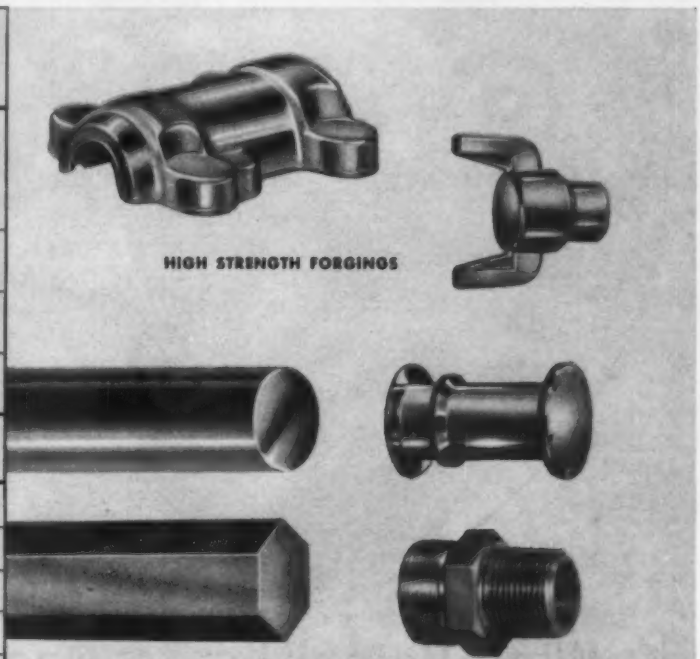
lower costs and improve your products

Mueller Brass Co. engineers and metallurgists are always ready to assist in the selection of the proper alloy for your particular product.

Regardless of your responsibility... design, specification, production or purchasing... Mueller Brass Co. special alloys can help you lower costs and improve your products. Call the "Man From Mueller Brass Co." today and put these remarkable alloys to work on your toughest jobs.

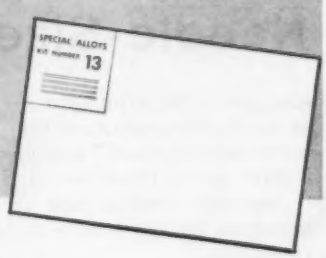
Yield Strength at 0.5% Extension Lbs./Sq. In.	Tensile Strength Lbs./Sq. In.	Relative Machinability Free Cutting Brass=100%
50,000	82,000	30
65,000	100,000	30
62,000	95,000	35
70,000	90,000	30
65,000	105,000	20
35,000	85,000	60
60,000	90,000	25
55,000	78,000	35
65,000	85,000	65
55,000	75,000	80
45,000	70,000	55
55,000	78,000	25
68,000	115,000	35
40,000	43,000	90



HIGH STRENGTH FORGINGS

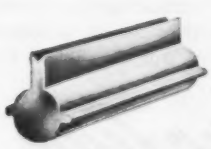
ROD SHAPES FOR SCREW MACHINE PRODUCTS

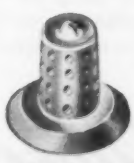
For further information on these alloys write today for Special Alloys Kit No. 13. Engineering information on other fabricated products is also available... please specify the manual you desire.



ALL THESE QUALITY PRODUCTS

SAND CASTINGS





CUSTOM EXTRUDED PLASTIC SHAPES AND INJECTION MOLDINGS

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

PORT HURON 28, MICHIGAN

301

Circle 1109 on Page 48-B

TubeXperience in action

Wind Velocities to Mach 7 Prove Needle-Size Superior Stainless Tubing

Manometer lines of Superior Type 304 stainless tubing, drawn to needle size, withstand the vibration caused by air speeds beyond Mach 7 and internal pressures as high as 5000 psi in FluiDyne wind-tunnel tests of missile component models. And they have been in some assemblies for 3½ years without cracking, pinholing or buckling.

FluiDyne Engineering Corp., one of the major designers of such test facilities, attributes the long life of this Superior tubing to both its high modulus of elasticity and its resistance to the corrosive effects of mercury and soldering-flux acid.

Ductility is a big advantage, too. This permits the Superior tubing to be easily hand-bent into complex shapes for application in wind tunnels and readout equipment.

Filling stainless steel tubing orders that call for tiny needle tubing in gages from 6 to 33 or tubing with OD's as large as 1.125 in. calls for the resources Superior has to offer. Why not investigate us as a source of small-diameter stainless tubing. Catalog 21 describes the types and analyses available. Also gives tips on its selection and application. Superior Tube Company, 2008 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

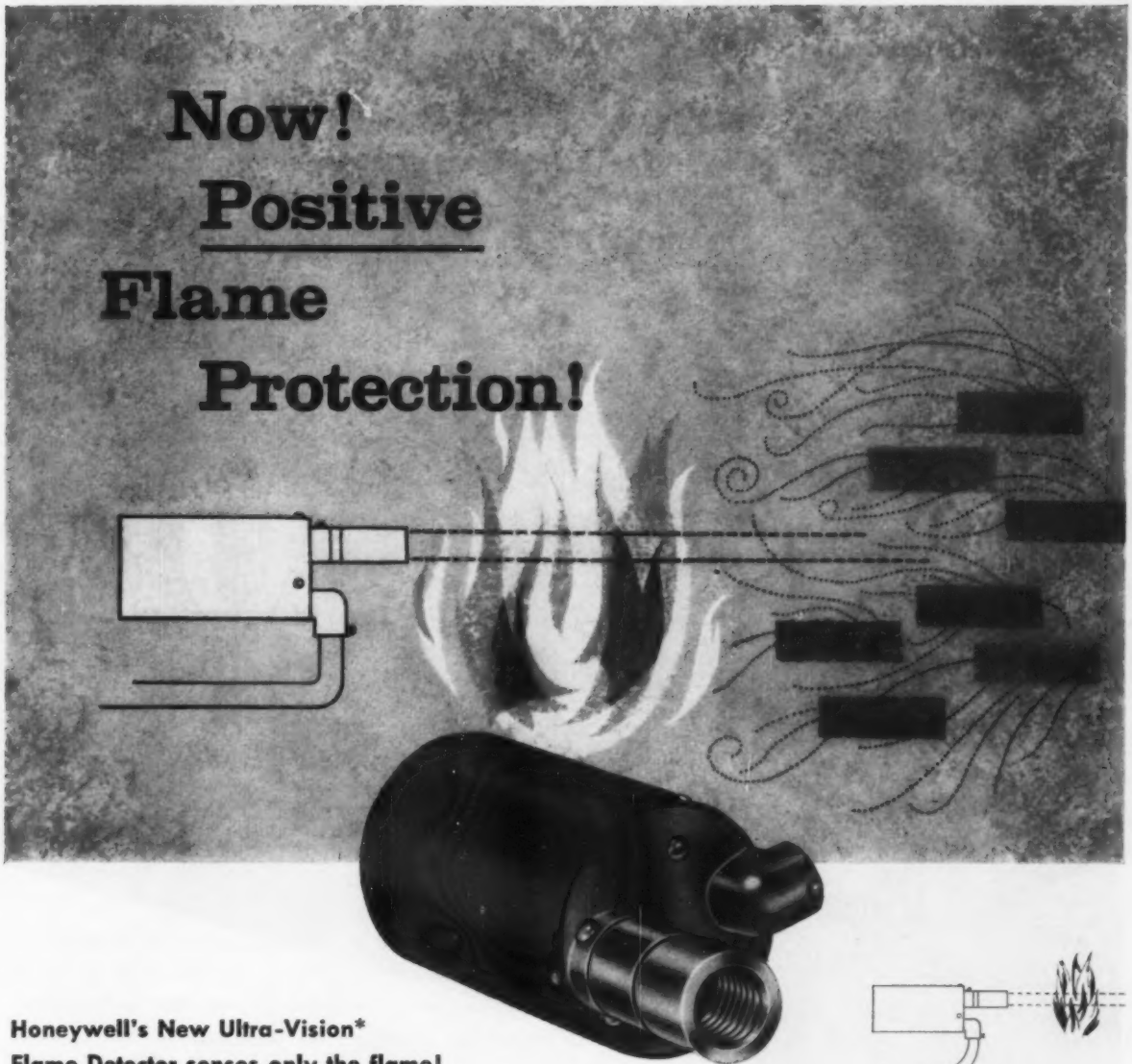
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Circle 1110 on Page 48-B

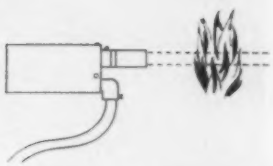
Now! Positive Flame Protection!



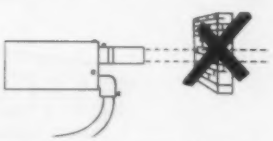
Honeywell's New Ultra-Vision* Flame Detector senses only the flame!

No more hot refractory hold-ins! This new Ultra-Vision Flame Detector responds to nothing but the ultraviolet energy given off by flame and sparks. It's the *only* visual flame detector that can tell the difference between real flame and red-hot refractory or glowing carbon. At last you can be *absolutely sure* that fuel delivery will be stopped in the absence of flame.

Only this compact new control simplifies flame supervision of both single and multiple burners. The Ultra-Vision Detector, not being sensitive to a hot refractory, can be aimed at each individual flame in the most convenient way. Actually pays for itself in simplified installation and maintenance. For all gas, oil and combination gas-oil installations. Get complete details from your nearby Honeywell field engineer. Call him today. Or, write for Bulletin 95-2776, Minneapolis-Honeywell, Minneapolis 8, Minnesota.



Ultra-Vision Flame Detector sights flame of all fuels.



Not affected in any way by a hot refractory or glowing carbon.

* *Trademark*

Honeywell

First in Control

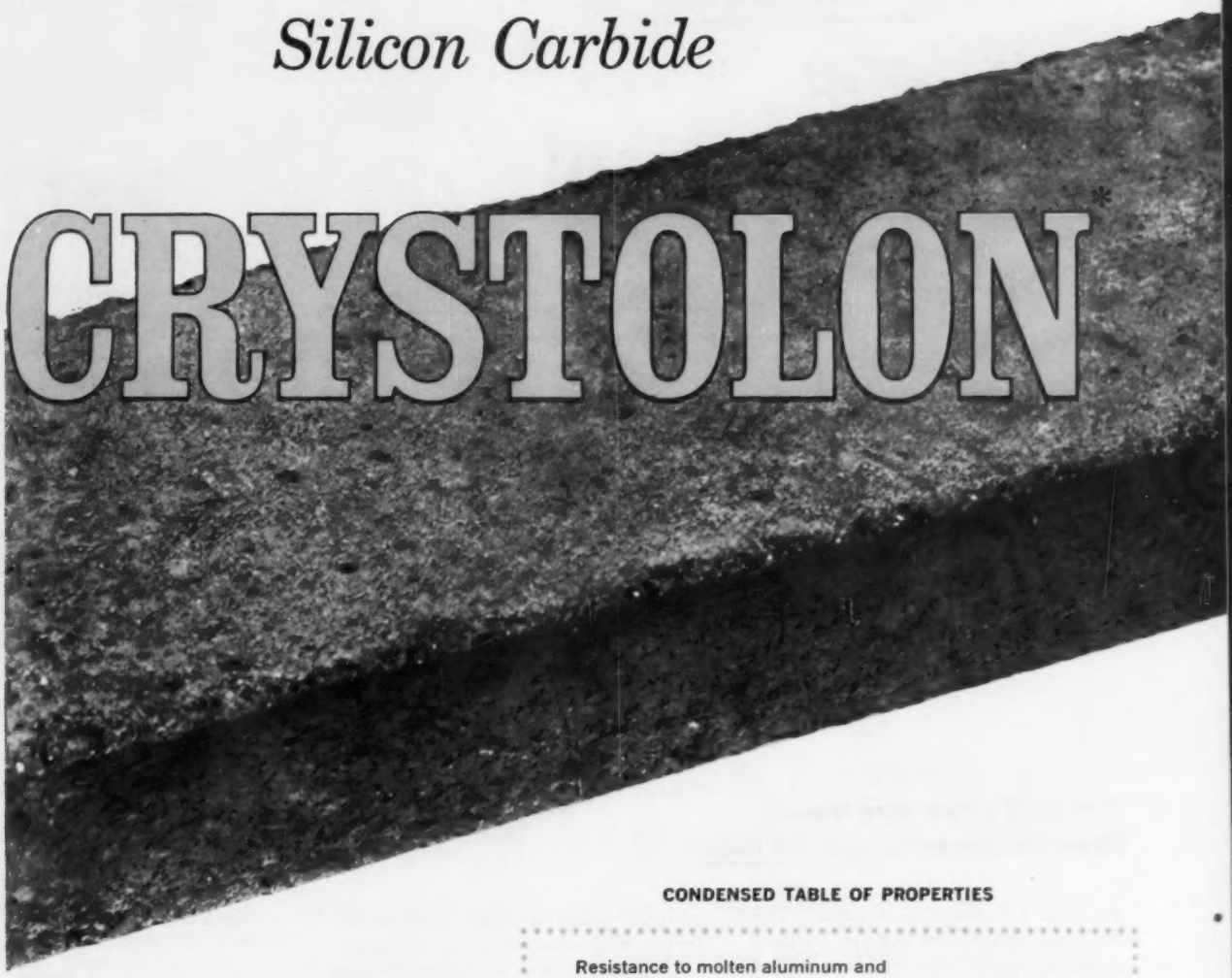
SINCE 1885

75th YEAR — PIONEERING THE FUTURE

Circle 1111 on Page 48-B

Now...use Nitride-Bonded Silicon Carbide

CRYSTOLON*

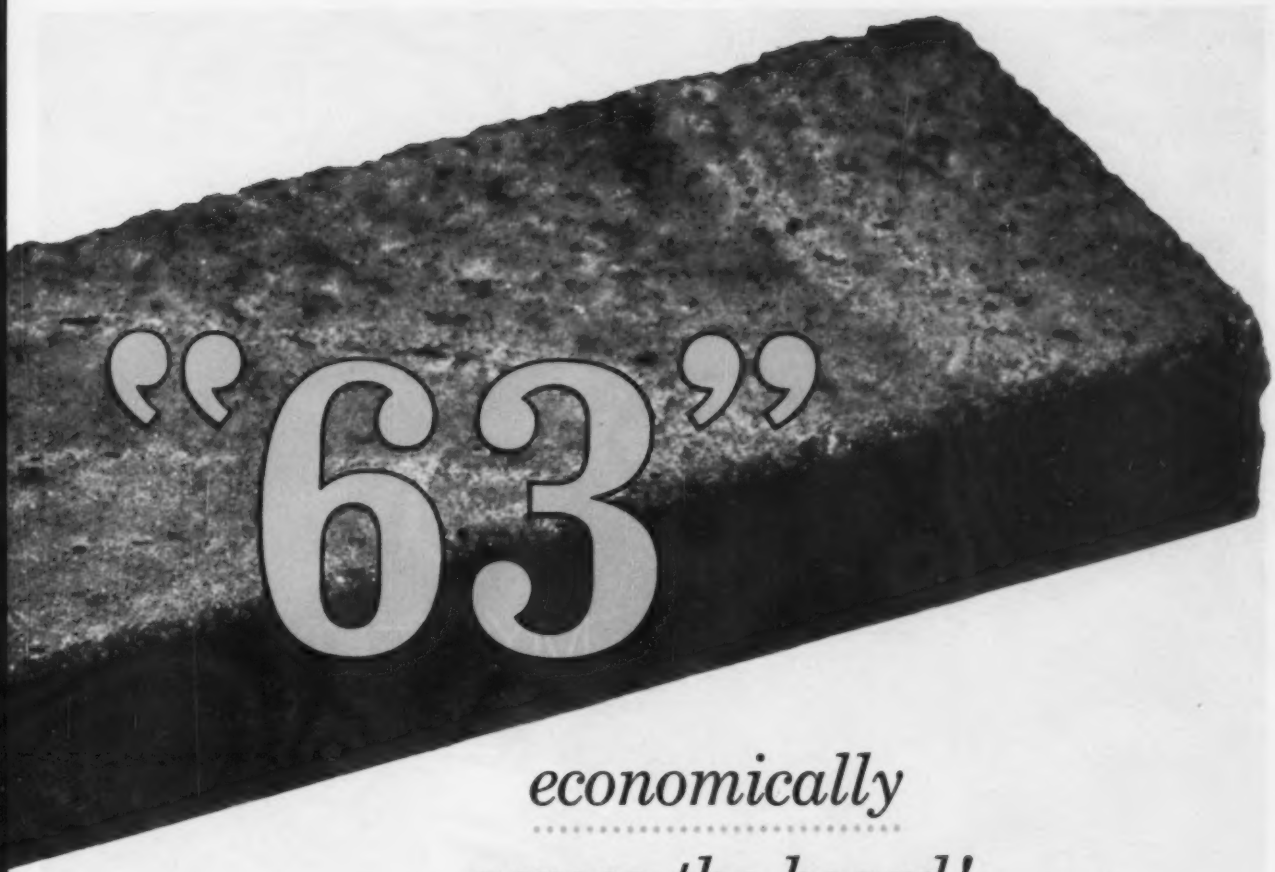


CONDENSED TABLE OF PROPERTIES

Resistance to molten aluminum and molten cryolite at 1000°C	Excellent
Fired Density	2.60 g/c.c.
Wear Resistance	Excellent
Oxidation Resistance	Excellent
Modulus of Rupture	
Room Temperature	6400 p.s.i.
1250°C	7000 p.s.i.
1450°C	3800 p.s.i.

Test procedures available on request.

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes



economically

...across the board!

Now, the best-performing silicon carbide refractory is available at a realistic price! Brand-new CRYSTOLON "63" permits the use of a cost-saving nitride-bonded silicon carbide refractory for hundreds of applications.

Produced by an exclusive Norton process, CRYSTOLON "63" Silicon Carbide provides all the superior properties of nitride-bonded silicon carbide at a *new low cost!* It has high thermal conductivity, excellent heat shock and wear resistance, and good resistance to most corrosive liquids. In extensive tests, it not only showed excellent resistance to "wetting" by molten non-ferrous metals (aluminum, magnesium, zinc, lead and others) but also to fused salts, such as cryolite!

Use CRYSTOLON "63" refractories for all the *tough* jobs: aluminum reduction cell linings, non-ferrous melting furnace refractories, metal transfer systems, slag hole blocks, chemical reactor linings, high strength kiln furniture, incinerator linings and for handling corrosive salts. *Send for complete details and properties — and let us quote on your requirements.* Write NORTON COMPANY, Refractories Division, 328 New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U.S. Pat. Off. and Foreign Countries

NORTON

REFRACTORIES

Engineered... Rx ...Prescribed

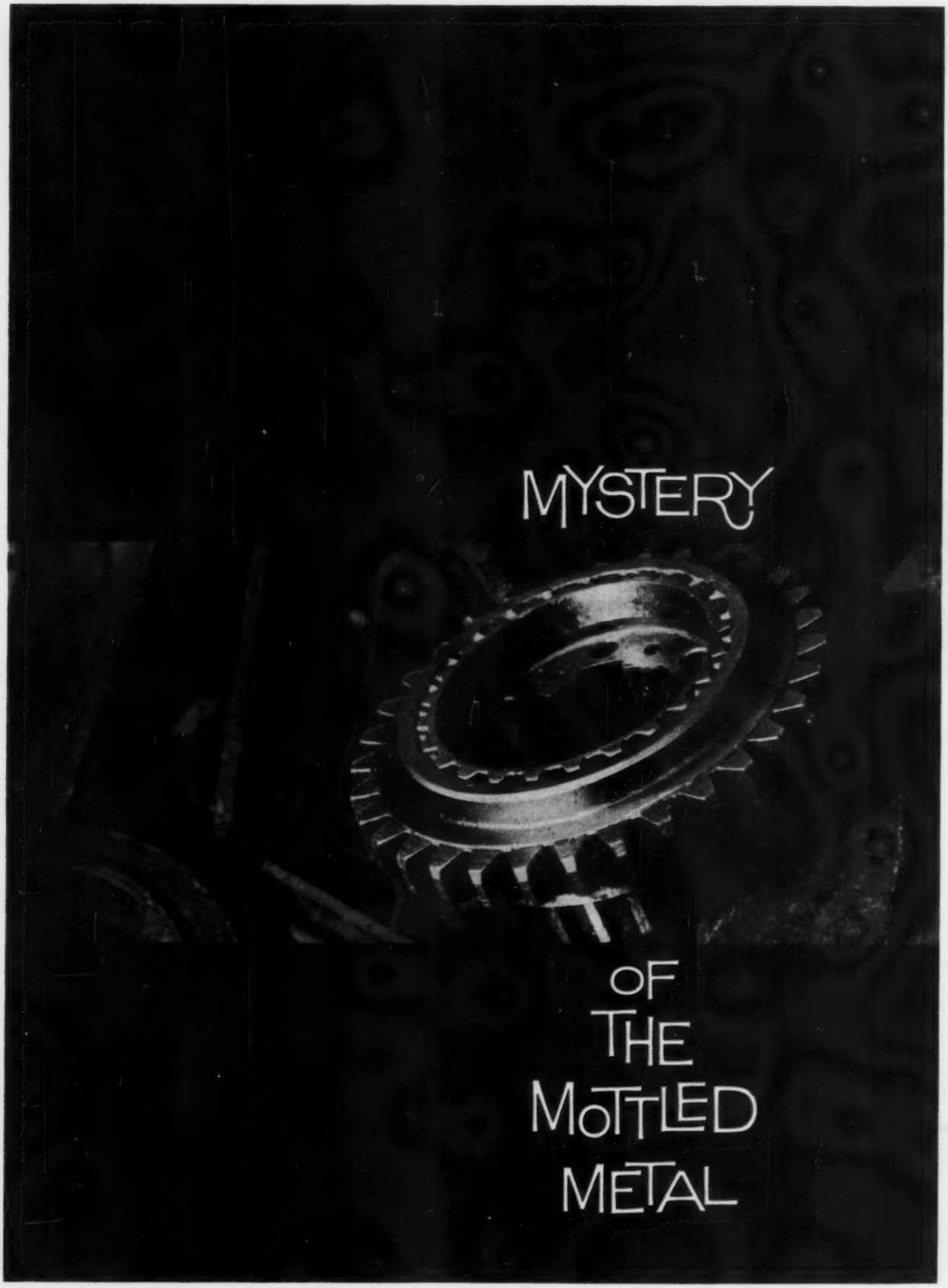
75 years of

Making better products

...to make your products better

MACHINE TOOL DIVISION: Grinding and Lapping Machines — G & E DIVISION: Shapers • Gear Cutting Machines • Gear Induction Hardeners

Circle 1112 on Page 48-B


MYSTERY
OF
THE
MOTTLED
METAL

OR **how to degrease more parts per dollar of cleaning cost**

X marks the spot where this company's vapor-degreasing troubles began to pile up. Parts coming out of the degreaser should have been shiny, bright. But they weren't.

Clue: There was a fatal weakness in the solvent. It was stabilized—but it didn't have the staying power to take rack after rack of parts loaded with acid cutting oil. Few solvents do.

PSP TO THE RESCUE Now this company buys a degreasing solvent that does not wear out prematurely. A solvent that can't "go sour" without notice and start staining parts instead of cleaning them. A solvent that cuts degreasing cost, because it lengthens the time between degreaser cleanouts by weeks or even months.

You can get this degreasing solvent, too. Just ask for Nialk TRICHLOR. You don't have to worry about its stability. You don't have to add fresh stabilizer. Even the vapor in the bath is stabilized. And you use less of this solvent, because less goes down the drain in needless cleanouts.

For more facts on what you can save with this better, more stable trichlorethylene, give your Nialk TRICHLOR distributor a call. Today.

NEW 36-PAGE BULLETIN explains fully how you get more and better vapor degreasing for the money with Nialk TRICHLOR. Shows basic types of vapor degreasers. Discusses cycles, operating procedures, stabilizers, causes of solvent contamination, solvent recovery, trouble shooting. Ask your distributor for a copy, or write us.

Nialk® Trichlor, a product of

HOOKER CHEMICAL CORPORATION

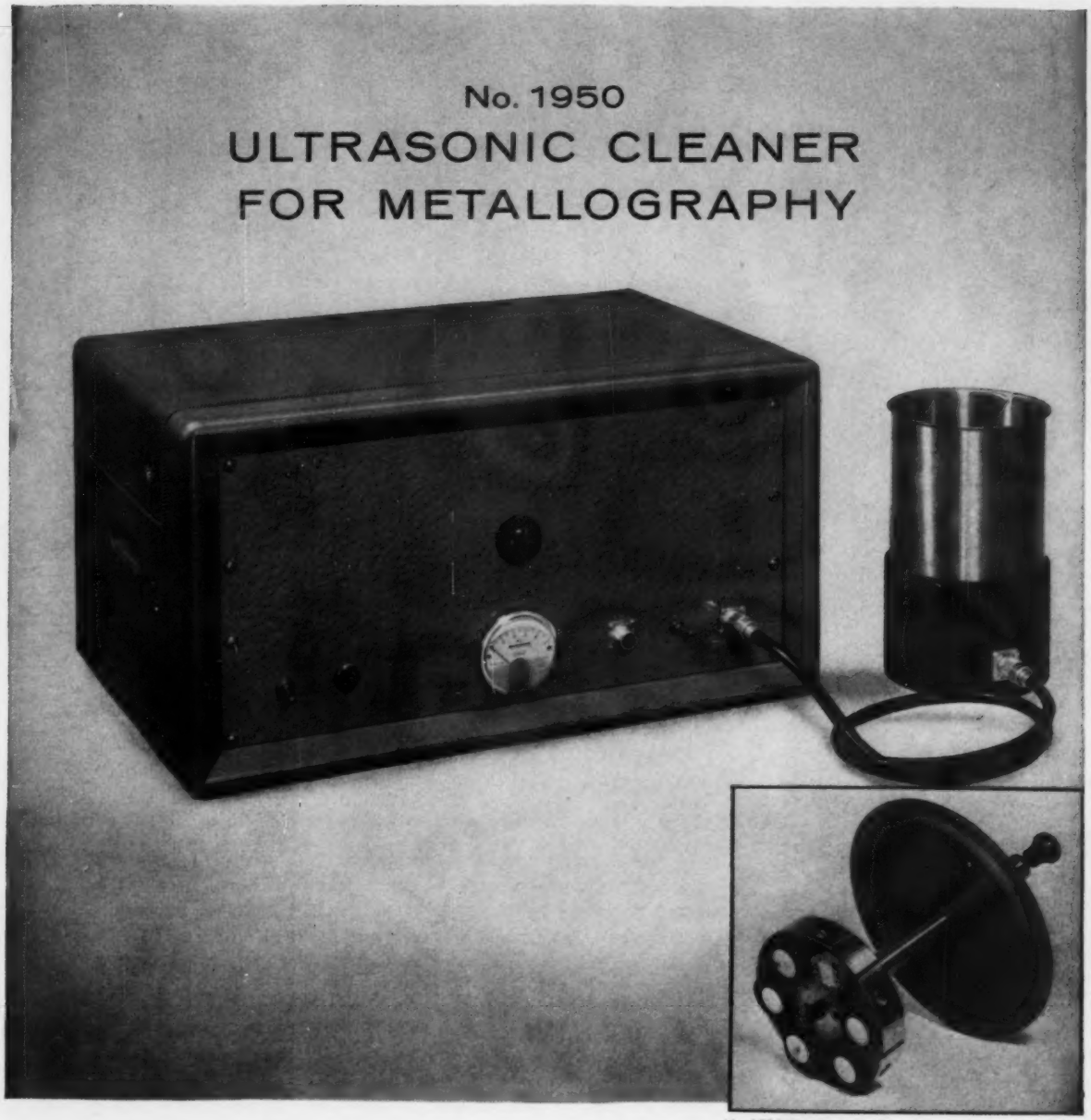
409 UNION STREET, NIAGARA FALLS, NEW YORK

Sales Offices: Buffalo Chicago Detroit Los Angeles New York Niagara Falls Philadelphia Tacoma Worcester, Mass. *In Canada:* Hooker Chemicals Limited, North Vancouver, B.C.

HOOKER CHEMICALS PLASTICS

No. 1950

ULTRASONIC CLEANER FOR METALLOGRAPHY



No. 1952 Positioning Clamp and Automet Holder

This new scientific development is ideal for cleaning metallographic specimens. It removes the hazard of carrying abrasive particles from a coarse grinding stage on to a finer grinding stage. The cleaning is accomplished quickly, thoroughly and at low operating cost. No skill is required. Additional speed and convenience is achieved by using an additional Transducer Beaker. The positioning clamp is required to accommodate the specimen holder from the Buehler Automet automatic polishing attachment.

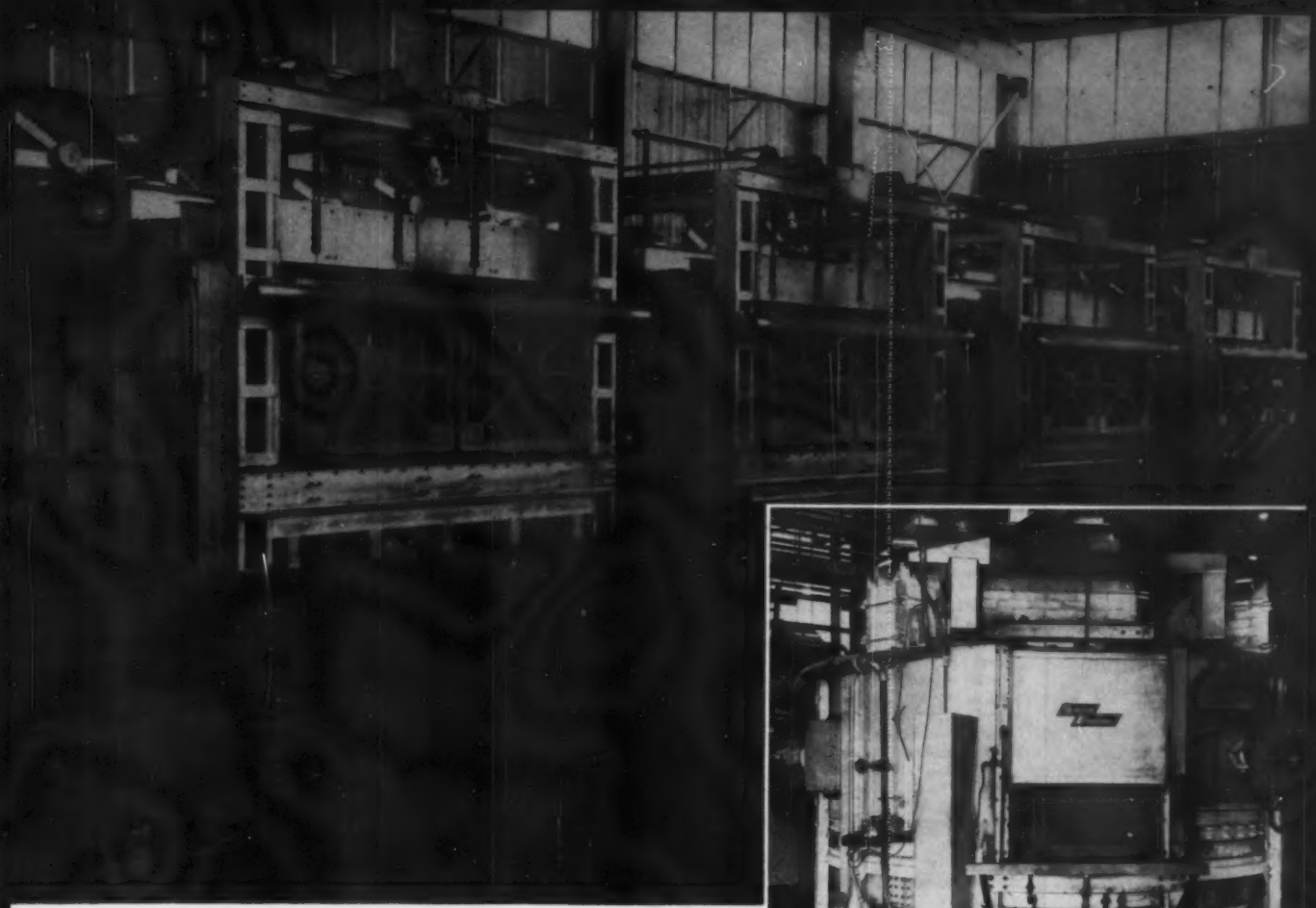
No. 1950	ULTRASONIC CLEANER	$495.00
No. 1951	EXTRA TRANSDUCER BEAKER	$130.00
No. 1952	POSITIONING CLAMP for Automet Holder	$ 22.00

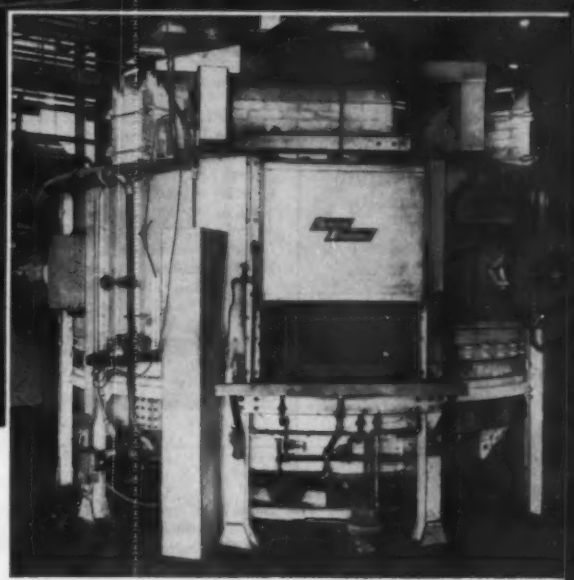
Buehler Ltd.

METALLURGICAL APPARATUS

2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

Circle 1114 on Page 48-B





Forge shops save money and increase production with these Salem-Brosius furnaces

Salem-Brosius furnaces are favorites in shops that forge stainless steels, titanium, zirconium, aluminum, and many of the refractory alloys used in jet engines and missiles, as well as the full range of carbon steels generally employed. The battery of batch furnaces above is now in continuous operation in the plant of one of the nation's outstanding forgers of newer alloys. The rotary hearth furnace below heats bar stock for closed-die automotive forgings.

Forge shop operators specify Salem-Brosius furnaces because they are built for long service life with common-sense structural, refractory, and mechanical characteristics. Designed for manual or automatic charge and discharge, rotaries such as this offer efficient, low-cost heating. They can be manually or automatically controlled, and offer assurance of fast and uniform output at high speed in a minimum of floor space.

Whether you require these or any other type of heating or heat-treating furnaces, Salem-Brosius can build them. Call us today.

Salem-Brosius, Inc.

PITTSBURGH, PENNSYLVANIA

Circle 1115 on Page 49-8

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Kentanium* (titanium-base carbides)	Superior strength and abrasion resistance at temperatures 1800°F. and up . . . temperatures that rapidly destroy conventional carbides or high temperature cast alloys. Can be subjected continuously to operating temperatures up to 2200°F., and up to 5000°F. for short periods. Greater resistance to thermal shock than ceramics. Highest stiffness-to-weight ratio of any material . . . approximately ⅓ the weight of steel. YME up to 60 million psi.	Sensing elements for high temperature thermostatic controls. Spinning tools for hot metals. Flash-trimming tools. Turbine components. Balls for pump check valves. Nuclear reactor equipment. Rotary seal rings. Hot rod mill guide inserts. Anvils for spot welding. Balls for hot hardness testing.
Refractory Carbides	High purity. High melting point—5000°F. to 7000°F.	In powder form as basic materials. Acid resistant parts and crucibles. High temperature furnace parts.
Heavy Tungsten Alloys	Nominal Density: 16.5 to 18.7 gm/cc. Machinability? Good. Tensile Strength: 40,000 to 90,000 psi. Corrosion Resistance: Excellent. Readily brazed with Easy-Flo No. 3 Compound. Available as bars, rods, rings, discs, special shapes.	Counterweights. Radioactive shielding. Isotope containers. Atomic watch shielding. Shielding—cobalt and X-ray medical equipment. Rotational parts—flywheels, governors, gyroscope components. Electrical contactors for high current, heavy duty applications.
Niobium	Metal—99.8% grade. Granules, arc melting electrodes, bar, strip. Metal—99.5% and technical grades. Powders, granules, arc melting electrodes. Oxide—99% and 99.5% grades. Fine powder.	Arc melting electrodes: Nominal size 1″ x 2″ x 20″. Niobium-base alloy electrodes also available. Powders: 20 to 80 mesh. Granules: 1/16″ to 40 mesh.
Tantalum	Metal—99.9% (capacitor) grade. Solid form—strip, bar, wire. Metal—99.5% grade. Granules. Metal Powder—99.8% grade. Fine powder. Oxide—99% grade. Fine powder.	Anodes: Sintered for both liquid and solid electrolytic capacitors, wide range of sizes. Strip: .001″ to .100″ thick, up to 12″ wide. Wire: From .005″ to .030″. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.

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Circle 1117 on Page 48-B

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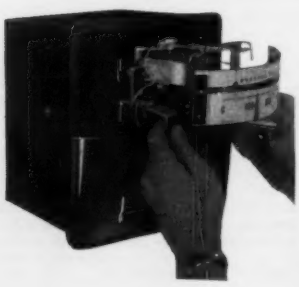

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Circle 1118 on Page 48-B

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Circle 1119 on Page 48-B

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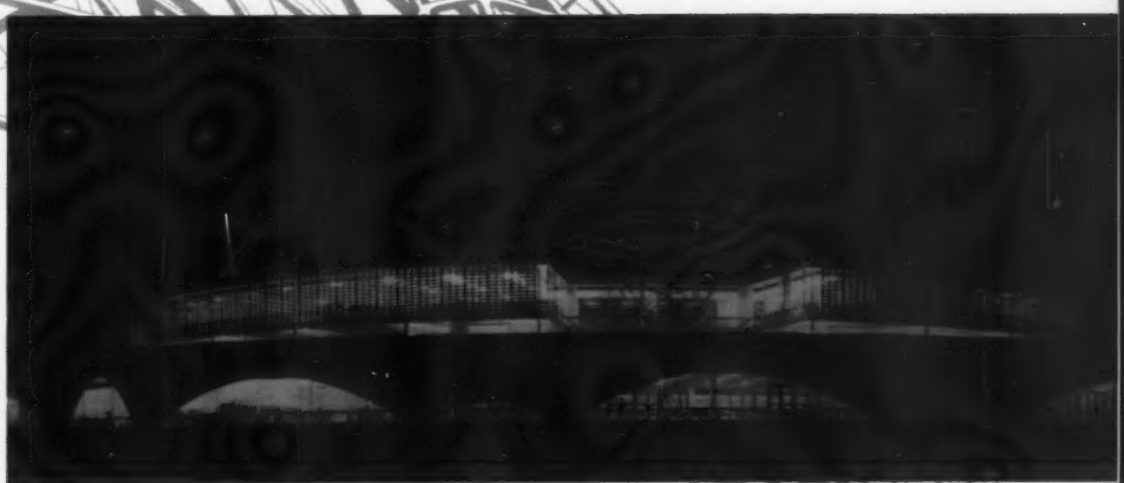
DEDICATION

September 14, 1960



The National Headquarters
of the American Society for Metals

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1921	Albert E. White*	1935	B. F. Shepherd	1949	H. K. Work
1922	Frank P. Gilligan*	1936	R. S. Archer	1950	A. E. Focke
1923	Tillman D. Lynch*	1937	E. C. Bain	1951	W. E. Jominy
1924	George K. Burgess*	1938	G. B. Waterhouse*	1952	John Chipman
1925	William S. Bidle*	1939	W. P. Woodside*	1953	Ralph L. Wilson
1926	Robert M. Bird*	1940	J. P. Gill	1954	James B. Austin
1927	J. Fletcher Harper*	1941	O. E. Harder*	1955	George A. Roberts
1928	Frederick G. Hughes*	1942	Bradley Stoughton*	1956	A. O. Schaefer
1929	Zay Jeffries	1943	H. J. French*	1957	Donald S. Clark
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1933	William B. Coleman*	1947	A. L. Boegehold		
1934	William H. Phillips*	1948	Francis B. Foley		

*Deceased.

Zay Jeffries

Zay Jeffries is rightly called the dean of American Metallurgists. While still a teacher at Case Institute of Technology, he teamed with R. S. Archer to produce "The Science of Metals" and its epochal slip interference theory of the hardening of metals. Later at General Electric Co. he became leader of its Carboloy subsidiary and of its chemical department, and since "retirement" in 1950 he has retained many of his former contacts in a consulting capacity. His long and generous service to the American Society for Metals at a national level has warranted its highest honor, the title of Honorary Member.

Clyde Williams

Clyde Williams is best known as the former president and director of Battelle Memorial Institute. In 1958 he founded a management consulting firm, to assist companies in applying science and technology to their business. A long time member and friend of the American Society for Metals, he has served as a director, trustee and committee member of numerous organizations including U. S. Chamber of Commerce, National Association of Manufacturers, Atomic Energy Commission, Rand Corp., and Hoover Commission. Dr. Williams has demonstrated keen insight into ways for producing and applying metals.

Dedication
American Society for Metals
National Headquarters

September 14, 1960 — Metals Park, Ohio — 1:30 P.M.

Walter Crafts, presiding
President, American Society for Metals

Invocation . . . . . *Rev. Maxfield Dowell*
Christ Episcopal Church

Opening and Introductions . . . . . *Walter Crafts*

An Appreciation of William Hunt Eisenman
and Unveiling of the Bust . . . . . *Zay Jeffries*

Dedication Address:
The Essential Link . . . . . *Clyde Williams*

Presentation of Headquarters . . . . . *Walter Crafts*

Acceptance Remarks and Placement
of Time Capsule . . . . *Allan Ray Putnam*

Inspection Tours

THE 5 FOUNDERS

A. E. White

W. P. Woodside

T. E. Barker

A. G. Henry

W. H. Eisenman

Forty years ago on September 14, 1920, the vision of the Founder Members began to be realized with the amalgamation of the Steel Treating Research Society and the American Steel Treaters' Society to form the American Society for Steel Treating — later broadened in scope and renamed the American Society for Metals. A. E. White, first president of the combined Societies, was chairman of the amalgamating committee from whose meetings "the superstructure of the American Society for Steel Treating was outlined, constructed and cemented together".

The soundness of their organizational structure has since been amply demonstrated. This structure resulted in large part from the recognition by W. P. Woodside, organizer of the Steel Treating Research Society, and A. G. Henry, secretary-treasurer of the American Steel Treaters' Society, of the need to bring together the practical man and the technical man, and of the importance of freedom of initiative for local chapters. The new Society was given direction by T. E. Barker, president of the American Steel Treaters' Society, whose broad vision encompassed virtually all of the current activities of the Society, even including ". . . our own well-appointed building which will provide suitable offices for our national headquarters". Barker also attracted W. H. Eisenman whose dynamic personality was the embodiment of those ideas that today constitute the American Society for Metals.

The concept of a new headquarters as an inspiring symbol of the Society's intention to serve the metal industry was Eisenman's alone. He searched widely for a creative architect with a sense of faith in metals, and chose John Terence Kelly. Built on land donated by Eisenman and financed by the Society, without seeking contributions, the building's bold design embodies the initiative and strength visualized by the Founders. A. P. Ford represented the Society during the construction period, and by his devoted vigilance contributed greatly to many functional features of the new headquarters.

Since breaking ground for the building, we have lost the guidance of our Founder Member, Secretary, and primary architect, William Hunt Eisenman. Forced to chart our own course, we have re-evaluated our objectives and the structure of our organization. We have reaffirmed that our primary goal is to foster education, advance knowledge and communicate new engineering information on metals and related materials. We have enlarged and strengthened the national committee structure so members will have more opportunity to enrich our services with their ideas. We have found an imaginative and energetic managing director, Allan Ray Putnam, to direct our efforts.

On this occasion, we are not only dedicating a new Headquarters but we are also rededicating the American Society for Metals — its staff, committees, and chapters — to an even greater effort to serve each member, industry, our Nation and humanity in the inspiring spirit of the Founder Members.

Walter Crafts

Walter Crafts, President
American Society for Metals

The Beginning . . . a roof of sky soaring above a mineral garden . . . Eisenman and Kelly

William Hunt Eisenman

1886-1958

A Biographical Memoir
by Zay Jeffries

Born on July 7, 1886, in Jamesville, Ohio, William Hunt Eisenman spent the first 32 years of his life mainly in educating himself and in helping others to become better educated. His father was an Episcopal minister and for a time he planned to follow in his father's footsteps. Eisenman's brilliance was evidenced early, having received his Bachelor of Philosophy at Kenyon College before he had reached the age of seventeen. He then attended Leland Stanford University for three years where he received his Master of Science degree, majoring in chemistry. He then enrolled at Morningside College, Sioux City, Iowa, and after one year received the degree of Master of Arts. Next he tried his hand at teaching. For three years he was principal of the high school at Olathe, Kan.

Still thirsting for knowledge, he enrolled for the 1910-1911 school year at Ohio State University. Then he taught chemistry for three years at Racine College. In 1914 he became superintendent of public schools at Elmhurst, Ill. The Elmhurst activity had a profound effect on Eisenman's future. One of the attractive teachers, Mildred Randle, caused him to devote less and less time to his school work, but, exhibiting an ability which was to manifest itself many times in the future, he solved the problem: They got married!

In Elmhurst also lived a metallurgist, T. E. Barker, who was sufficiently interested in the public schools to realize that Eisenman was a great educator. Barker had a vision which for realization required the services of an educator *and* a manager. Let us follow the events up to Barker's vision:

In the fall of 1913, a group in Detroit sensed the need for spreading information about the heat treatment of steel in the rapidly expanding automobile plants. They formed a club later incorporated as the Steel Treating Research Society—and none too soon, for American industry (then on a carbon steel basis) got into the manufacture of munitions, much of which required alloy steel and heat treatment. Barker, although he was living in the Chicago area, joined this group and in

Bill Eisenman . . . holding a piece of titanium.

Early A.S.M. Chapter Visit . . . Eisenman second from left

due course a Chicago Chapter was formed. The parent Detroit organization did not seem to give proper consideration to the Chicago Chapter, so in 1918 the latter seceded and formed the American Steel Treaters' Society with Barker as president. Perhaps another reason for secession was a feeling that the objectives of the Detroit group were not ambitious enough. At any rate, Barker's vision was exceedingly ambitious. It featured educational activities and information services in steel treating. Without funds and with a great idea, he sought to interest Eisenman in taking over as business manager, not only to realize the ambitions but also to make the venture pay its own way (including Eisenman's salary). Eisenman accepted the challenge.

Soon his genius as an organizer was recognized. Eight new chapters were formed in his first three months, and the membership increased at a fast rate.

I am of the opinion that the late Prof. A. E. White, associate professor of metallurgy at the University of Michigan, who was then president of the Steel Treating Research Society, sensed that the objectives of the American Steel Treaters' Society were essentially the same as those of his own group, that there was much overlap in membership (Pittsburgh, for example, had chapters of both Societies) and that the Detroit group had no one comparable to Eisenman to manage its Society. After considerable maneuvering, a merger was effected in 1920 by forming the American Society for Steel Treating with A. E. White (of the Detroit group) as its first president, W. H. Eisenman (of the Chicago group) its Secretary-Manager, and Cleveland (neutral territory) as the home office. This was the predecessor to the present American Society for Metals (1933).

Lest it be thought that this merger solved all or even most of the problems incident to launching such an ambitious venture, we should not forget the early struggles for existence. There was the expected concern by some of the older societies about conflicts of interests. The dues were small, $10 per year, and more than one third of this was refunded to the individual's chapter. Publication of the *Transactions* was expensive. Staff assistance had to be provided. Headquarters rent had to be paid—and so on and on. At times there was not enough money to take care of the payroll.

1957 A.S.M. Chapter Visit . . . Eisenman second from left

In the face of these difficulties, Eisenman proved his genius as a business manager. Arthur Henry, secretary of the American Steel Treaters' Society, put on the first steel treating exhibit in Chicago in 1919. Eisenman saw in this activity a dual opportunity to render service to industry and to bring in needed funds to the Society. At the Philadelphia annual meeting in 1920 he established the pattern of the National Metal Congress and Exposition. In the years following, the exposition has been a great financial success and the handsome exhibit of crystalline copper on the plaza of this new Headquarters, the gift of the National Association of Exhibit Managers, is a tribute to his 20 years of leadership of that group and to his wisdom in planning and supervising no less than 54 expositions, up to the time of his death.

After the Society had been operating for about 20 years, I was made an honorary member and in my response to the award I tried to analyze some of the factors which had contributed to its success. I viewed the Society at that time as a person who had been active not only in it but also in other technical or professional societies. Here is what I said in 1939:

"The American Society for Metals is the technical society phenomenon of our generation. There must be a sound foundation for such a success. In trying to assay the building-blocks of this foundation some things stand out clearly.

"From the beginning there has never been the thought that the Society was an end in itself, but rather the means to an end — service to its members and to industry. Members have not been asked to join to help the Society, and exhibitors have not been asked to take space to help the Society, but to help themselves.

"It seems to me that we may truly say that the American Society for Metals represents the mass production, low-cost principle applied to technical society service. The dues are unbelievably low for the advantages offered, and the only qualification for membership is a desire to join.

"Again, the Society was a pioneer in bringing service to the membership through local chapter activities. These activities were financed by allocating a generous share of the membership dues to the local chapters. Of course many services, such as the publication of the 'Metals Handbook', add to the attractiveness of membership.

"But there is, I believe, a master building-block in this sound foundation which has been largely responsible for the Society's phenomenal success. It is the harmonious marriage of the technical programs and the exhibits which we are now witnessing for the 21st consecutive year. Each complements the other. To the technical sessions come the metallurgists and other scientific workers to describe their new findings and discuss theories and practical applications. At the exhibit hall may be seen the physical embodiments of these new findings. Here also, within an area of a few acres, one can consult dozens of experts in all branches of the metal industry. The Society has not been afraid to join the technical and commercial people in its membership; it has faced the obvious situation that the technical and commercial must *both* be served. The meetings are essentially educational and technical, and the exhibits are essentially commercial.

"This harmonious marriage is an example of 'emergent evolution'. This is a term coined by students of life processes to indicate the rare instances of new and unexpected favorable characteristics in hybrids. Normally, if a member pays $10 per year dues, he should not expect to receive services costing more than $10. In the American Society for Metals he receives services costing from $20 to $40. The added service is made possible largely by the exhibit. The exhibit is possible only because of the technical meetings. Combined, they provide an inducement for

Leaders All . . . Eisenman, White, Jeffries

greater attendance than technical meeting alone. Other societies join to swell the ranks. The ultimate result is that the National Metal Congress and Exposition attracts the largest gathering in the metal industry. Furthermore, it attracts the key men. Thus does the metal industry put its stamp of approval on the service rendered by the Society.

"This solid foundation did not just happen. It is the result of much hard work on the part of many people. It reflects not only the diligent effort, but the genius of our Secretary, W. H. Eisenman."

You may have noted that I said nothing about *Metal Progress*. Both the "Metals Handbook" and *Metal Progress* were made possible by the financial success of the National Expositions. The Handbook, started in 1923 as a small set of 4 by 7-in. looseleaf data sheets in a ring binder, and growing through successive editions to its present encyclopaedic scope, has been an expense item from the beginning, since each copy has been sent to the members free of charge.

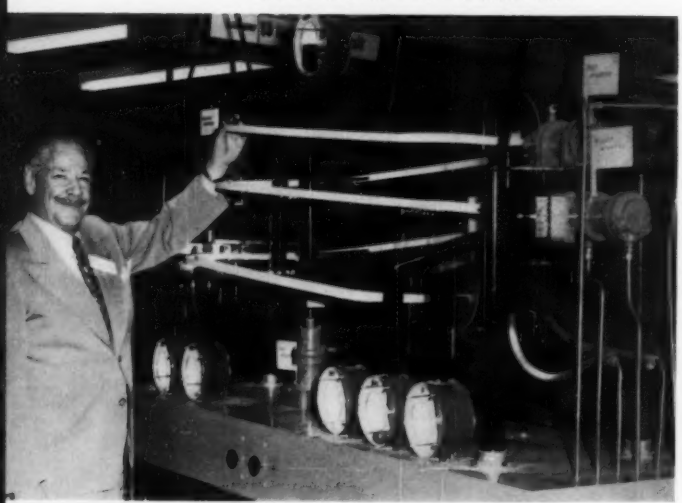
On the other hand, it was thought that *Metal Progress* would need to be "carried" for only a few years before it could pay its way. An amazing thing happened: Very modest losses occurred in only three of the depression years — 1933, 1934 and 1935. Having been active in Society affairs when *Metal Progress* was first published in 1930, I can say that the main emphasis was on quality, not profit. Eisenman insisted that the Society should put out a publication that was second to none in its field in appearance and content. It was to be in no sense of the word a "society publication", but an independent engineering journal. With this objective there was only one prospective candidate for editor. It was Ernest E. Thum. The desired excellence was not only achieved but also *Metal Progress* proved to be a great financial success — an outstanding example of the Eisenman principle that desirable activities of the Society could and should pay their own way.

I have already remarked that Eisenman's capability as an exposition expert was nationally recognized. It might be added that he was on the Advisory Committee of the Chicago World's Fair in 1933. He was also a member of the American Iron and Steel Institute, the Society of Automotive Engineers, the American Society for Testing Materials, the American Foundrymen's Society and held honorary membership in nearly all of the important European metallurgical societies. Notwithstanding his exceptionally busy professional life, he did not shirk his civic duties nor did he believe in all work and no play. In Cleveland he was a member of the University, Rotary, Cleveland and Chagrin Valley Clubs. He showed talent as an entertainer at many gatherings.

Let us recapitulate and note what abilities Eisenman had: He was an educator, an organizer, a manager (generally recognized as the best exhibit manager in the United States) and an entertainer. But he had another talent which probably should be at the top of the list. He was what might be termed a *practical* visionary. He could see further and more clearly than the rest of us. It could be said that Barker's original vision was enough to get the Society started. Eisenman had a herculean task to make that vision real. Barker actually visualized the issuance of data sheets which could have evolved into the monumental Handbook. But Eisenman's own vision was working all the while. One

Exhibit Managers . . . meeting in Atlantic City . . . Eisenman second from right

Off-Taken Scene . . . at a Metal Show



innovation followed another. Nearly all of them were successful.

Before covering what seems to be the final flowering of his vision, I should like to explore some of Eisenman's characteristics, mostly drawn from my own experience.

Although highly emotional, Eisenman could, when occasion required it, exhibit great calm. One time during National Metals Week I was in his office discussing a critical problem. There was a tough union jurisdictional dispute and it wasn't certain that the exhibit would open on time. A member from one of the out-of-town chapters came in to say hello. Eisenman exchanged greetings and acted as if everything was going smoothly. Soon the "fixer" came in and I watched him "out tough" the fixer. The exhibit opened on time!

None except perhaps his closest staff associates can tell about the many difficulties encountered throughout the years. He did not parade his troubles for the sake of telling them. When he told one his troubles he wanted help. He expected his associates to act in a similar way.

There was, during Eisenman's active service, a seldom mentioned provision in the constitution which permitted his re-election as Secretary every two years — a provision which also made him one of the trustees. His answer to a suggestion that he did not have to submit to re-election periodically was always the same. "Any time the members do not want to re-elect me, I do not want to serve."

The method of electing officers and trustees, established in the first constitution, worked all right for about 15 years. Then internal politics almost caused a split in the Society. A group of interested people on both sides of the controversy met one night until four o'clock the next morning and resolved the difficulties. Eisenman's reaction to all of this was severe self-criticism for not anticipating the trouble. He called for a temporary committee to revise the constitution in order to minimize the chances for any future schism.

Another time he had in mind the dismissal of one of the key staff men. He wanted to talk this over with me. In the end it seemed that the main trouble was that the individual would not conform. I reminded him that his own reputation as a conformer was not very high either. He looked at me a long time in silence as if this were a new thought. Of course any past officer or trustee can vouch for the fact that part of Eisenman's strength came from his nonconformance — especially so because his was constructive.

Eisenman's long siege with cataracts of the eyes revealed a capacity to endure suffering that was rare. He carried on his Society activities even from the hospital bed when necessary. Prior to one annual meeting I noted that he was hand printing his annual secretary's report in very large letters. "You see", he said, "this will make it possible for me to read my own report tomorrow." Up to that time I had no idea that his eyesight was very poor and I presume that few of the members realized this either. At the meeting he read his report, as he had so many times in former years, without indicating in any way that he had any visual impairment.

His name, Eisenman, is of course synonymous with "Iron Man", and this connotation could not have been more sorely tested than through the war years when he and his wife were grieving for Billy, Jr., lost early in an airplane crash, an only child, truly their hope for the future. How they staggered through no one can tell. Undoubtedly, their deeply religious faith in Christ the Comforter was the staff on which they leaned.

Over the years I have heard many expressions concerning Eisenman. Naturally they were not all favorable. No one can accomplish as much and initiate so many changes as he did and please everybody. Some of the terms used were "ruthless", "czar", "despot", and "stubborn". However, some of the people who used these terms at times more often joined the big chorus who used such terms as brilliant, genius, kindly, forceful, performer, leader, energetic, hard worker, considerate, man of decision and action, far seeing.

It should be evident that the achievements of the American Society for Metals would have been impossible without the guiding hand of a practical visionary. As Eisenman gained experience his plans became bolder and more ambitious. One of the outstanding accomplishments was an educational plan cherished since his days as school superintendent. This included chapter educational activities, provision for teaching aids, science students' awards, teaching awards, teachers' courses and other matters aimed at increasing the number of metallurgical students in the technical schools and universities. The American Society for Metals' Foundation was established with an endowment of $650,000, solely from the Society's surplus; and adding the income from the foundation to the other direct appropriations the annual expenditure for formal educational purposes has been around $50,000 for 12 or 13 years.

Among the honors conferred on Mr. Eisenman was the posthumous degree of Doctor of Laws, in 1958 from Western Reserve University. In the citation, President J. S. Millis said . . . "through Mr. Eisenman's vision the American Society for Metals has supported pioneering research in the development of electronic equipment for the organization and indexing of scientific information, and the development of systems for use with such

equipment." A Documentation Service unit has now been established and, in cooperation with Western Reserve University, information searching has been given the tempo of the electronic age.

This achievement pinpoints another facet of Eisenman's genius. It may well be concluded that this unique service evolved from the older *Review of Metal Literature,* which never met financial success. Eisenman had a passion for developing services which would be self-supporting. He felt that when potential users were not willing to pay the cost of a service the value of the service was questionable. Modern electronic searching is a reward for trial and error, study, patience and a five-year research into the theoretical and practical possibilities.

Another typical Eisenman innovation was the World Metallurgical Congresses. One was held in Detroit in 1951 with financial and other help from the European Economic Administration and another in Chicago in 1957 which the Society alone financed. Together these congresses attracted about a thousand foreign metallurgists and industrialists from nearly 40 countries.

The boldest and most ambitious of all of Eisenman's plans was formally presented to the Society when he was 68 years old. It was presented at the annual meeting in Chicago on November 3, 1954, under the title "The ASM of Tomorrow." The plan embraced five phases as follows:

1. The erection of an adequate new headquarters building (within two years).
2. The creation of a division of the A.S.M. to be known as the Metals Engineering Institute (in operation within two years).
3. The creation of a division to be known as A.S.M. Metallurgical Seminars (within three years).
4. The creation of a division to be known as the A.S.M. Metal Research Laboratory (as soon as practical!).
5. The creation of a division of the A.S.M. to be known as the Metal Science University (to follow the Research Laboratory).

The adequate headquarters has been erected; you have the visual evidence of its imaginative conception. Metals Engineering Institute has been in operation for three years, already enrolling nearly 4000 students. The seminar program is not active and the others are under study.

Eisenman died in a hospital in La Jolla, Calif., on May 30, 1958, a short time before his 72nd birthday. During the preceding five years he seemed, at times, to keep alive and active by sheer will power. Fittingly, his last Society work was managing the Dallas Exposition which ended only days before his sudden death. He seemed to sense that he would not live to put the whole of the above ambitious plan into effect but he had confidence that all of it would be capable of accomplishment. This is evident from his closing remarks. He wrote:

"I commend this program to you. It is no little plan. I hope you believe, as I do, with the eminent architect Daniel H. Burnham who said:

" 'Make no little plans; they have no magic to stir one's blood and probably themselves will not be realized. Make *big* plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever growing insistency.'

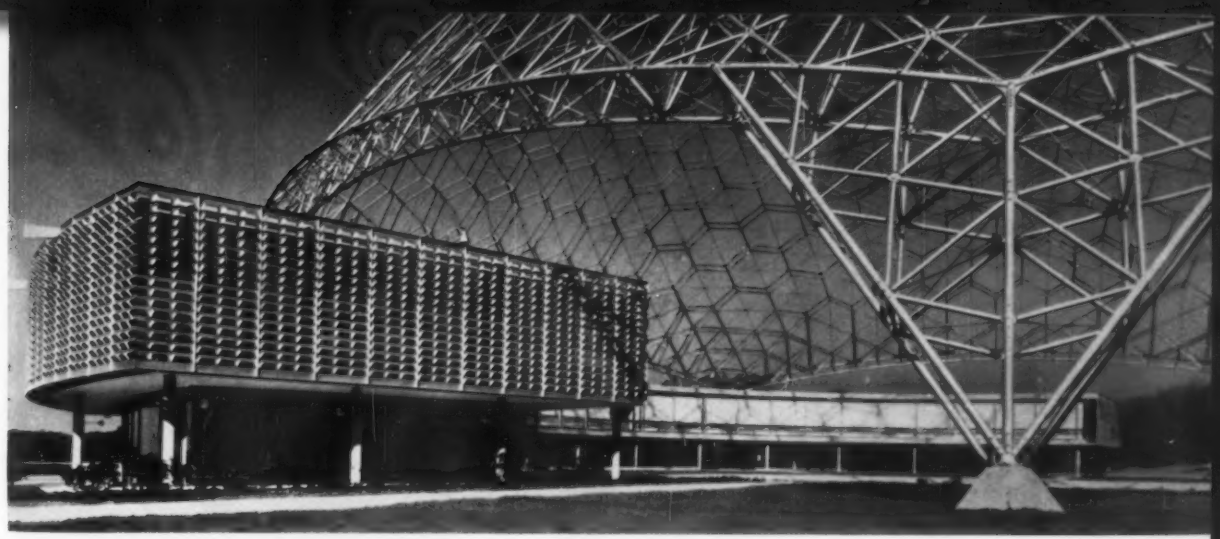
"Remember; let A.S.M. make no little plans! Let A.S.M. make only *big* plans, realizing that vision is indispensable to progress. I have presented this diagram of the A.S.M. of Tomorrow so that it may be recorded and made a part of the official record.

"You, the members of the Society, and the Board of Trustees, and all of us can fill out that diagram in every phase—and when it is completed, it will be a more finished and successful achievement than could possibly be created by a word picture of the most glowing eloquence. But to create and accomplish, we must have faith in the American Society for Metals as an instrumentality through which all of us, recognizing that the security and welfare of our civilization depend increasingly on the advancement of scientific knowledge, will have an opportunity to serve humanity, our industry, and our country.

"Hear A.S.M.'s call to greater service.
"If we listen and hear the call,
"And answer with a will and determination,
"No barrier can halt the progress of the A.S.M. of Tomorrow."

Documentation

The history of the American Society for Metals has been well documented in the detailed reports of the Secretary printed annually in Transactions. For summaries I suggest, in particular, reference to "A Tribute to the Chicago Chapter," by Dorothy Thum in *Metal Progress* for October 1947, p. 551; "William Hunt Eisenman, the Man and His Work" in *Metals Review* for June 1958, p. 7; "A Short History of the American Society for Metals," by Dorothy Thum, in *Metal Progress* for March 1940, p. 271; "A.S.M.'s New Headquarters," by W. H. Eisenman in *Metal Progress* for May 1958, p. 67; "Dedication of National Association of Exhibit Managers' Memorial to William Hunt Eisenman," by Roberts Everett. Obviously all accounts of the Society's history reflect the accomplishments of the main character, William Hunt Eisenman.



Sunshade in Stainless . . . geodesic dome in aluminum . . . looking north

A.S.M. and the future . . .

The challenge of the future for the American Society for Metals is exciting, and immense! It is a challenge that relates to the glorious past and to a growing future.

It was keen foresight of the five founder members that visualized the educational goals of the Society. The success of their initial planning is embodied admirably in this magnificent new headquarters.

Here, too, are reflected the long years of dedicated service to the A.S.M. member by William H. Eisenman. He recognized the vital importance of the A.S.M. member's contributions to industry. He concentrated his great abilities on the creation of services that would increase the importance of the A.S.M. member to industry.

Thus, the Society's first forty years of growth was based on service to the A.S.M. member. This is the challenge for the future. As this basic industry of metals and related materials expands, so must the Society meet, with its services, the needs of an ever-growing A.S.M. membership.

These services for the A.S.M. member of tomorrow must be multiplied to answer the demands of a growing technology. They must be increased in scope and value.

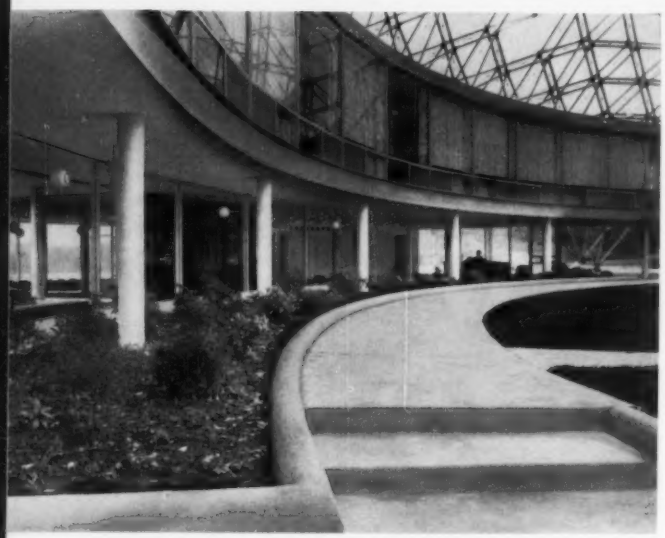
This is the challenge to the Society and to its headquarters staff assembled here in this fine new building—a challenge that demands creative leadership in continuing a dedicated service to the A.S.M. member.

Allen Ray Putnam

Managing Director
American Society for Metals

Lounge Area . . . upper level

The Sunshade . . . stamped in stainless, with welded eyebrows.



Plaza Level . . . looking to the Southwest

Allan Ray Putnam . . .
A.S.M. Managing Director

Condiments in the Cafeteria . . . uniquely designed for stainless steel and copper perforated in the pattern of the sunshade

The Board Room . . . panelled in Canadian birch, accented with stainless steel . . . contributed by Canadian A.S.M. Chapters

Floating Stairway . . . steel, with handrails of brass

Metal Progress

Vol. 78, No. 3 September 1960

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Technical NEWS in Brief

Nuclear Heat Converted to Electricity

Just as we went to press, Westinghouse Electric Corp. released some additional information on direct conversion of nuclear heat to electricity (see article on p. 108). William E. Shoupp, technical director of the corporation's atomic power department, reported that a thermionic and thermo-electric generator had been built into a nuclear fuel element. When inserted into a reactor, the device produced about 1 watt of power.

Purpose of this experiment, which was conducted by Peter J. McCoy, was to determine the feasibility of a dual generator embodying thermionic and thermo-electric principles. As pointed out in Dr. Shoupp's article, much of the heat energy in fuel elements is not readily accessible. Although the center of the element may be at 4000° F., the walls of the cylinder containing the fuel are only at about 680° F. To take advantage of the high heat energy in the fuel, Westinghouse built an element with a thermionic generator in its center. The device operates in vacuum and is basically a tungsten filament which emits electrons when heated by the nearby fuel (fissionable UO_2). The electrons travel across a gap and are picked up by a nickel anode. Thus heat of the fuel is converted to electricity.

This type of generator works best at 3500° F. For better efficiency at lower temperatures between 600 and 1800° F., a thermo-electric generator was built around the fuel element (see photo). The generators are connected in series to combine their electrical output.

Success of the feasibility study marks one of the first steps toward an economical heat conversion system. According to Joseph C. Danko, manager

W. E. Shoupp Examines Converter
Thermionic-Thermo-Electric Device Converts Nuclear Heat to Electricity

of direct conversion activities at Westinghouse, ". . . the development program will continue toward the goal of increasing the efficiency of the device".

Imports of Foreign Steel Maintained at High Rate

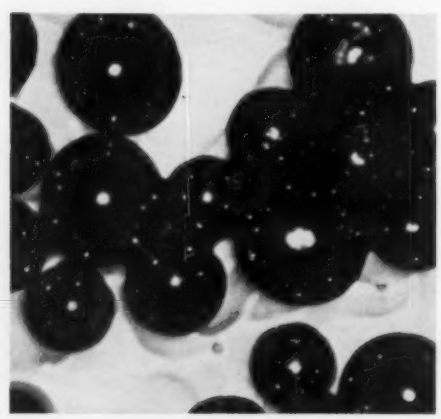
"Foreign Trade Trends, Iron and Steel", issued by the American Iron and Steel Institute, emphasizes that in 1959 exports of all steel mill products made in the United States fell to the lowest tonnage of any year in the decade (1,508,000 tons), principally due to curtailed shipments during the long steel strike. The document expresses the hope that gradual economic growth of industrialized countries now occurring outside the United States will reverse this unfavorable trend in exports. Imports of foreign steel, the principal shippers being Belgium, Luxembourg, France and West Germany, jumped enormously with rapid gains being registered in all products except rails. The high rate was maintained during the first quarter of 1960.

While the total imports of 4,392,000 ton amounts to only 3.6% of the U. S. production (93,000,000 tons), the sudden upswing is cause for worry.

Spherical Powders Made in Inert Atmosphere

Spherical metal powders with particles ranging in size from 20 to 150 microns are being produced by Linde Co., Div. of Union Carbide Corp. Since the powders are made in an inert atmosphere, the extent of voids, cavities and inclusions depends only on the purity of the metal wire used as a starting material. Uniformity rate is held to 98%; only 2% of the particles produced are not spherical.

Six metal powders – copper, aluminum, nickel, tungsten, Type 316 stainless and Nichrome – are available in limited quantities. Projected applications are where uniform size and spherical shape are important. Parts which require controlled porosity, such as filters, burner plates, and porous piston rings are good examples. Addition of 10 to 20% spherical particles may also improve flow of angular powders into molds and thereby result in better quality and production rates for sintered parts. When the process is extended to reactive metals such as Zircaloy-2 which has already been made on an experimental basis, it may reduce the hazards of handling such metals because particles have a lower surface-to-volume ratio.



TUNGSTEN PARTICLES AT 50 ×
Spherical Shape Means Better Sintered Parts

Oxygen for Steel Plants

One would look a long way for a better example of the rapid changes in the metals industries than to consider the use of oxygen in steelmaking. It seems that the first commercial trials were in the openhearths at Steel Co. of Canada (Hamilton) in 1942, when some oxygen was jetted through the burners with the air and fuel oil. Five years later, Linde Air Products Co. held an extensive meeting and tour for technical editors, and the report in *Metal Progress* for July 1947 used four pages to discuss methods and costs of various applications, existing but mostly proposed.

At that time the openhearth seemed to give the best opportunity, but roof temperatures appeared to be the limiting factor – the all-basic roofs, even then common in Europe, had not yet been built in America. Next, leap forward to September 1959, when consulting editor E. C. Wright printed a survey of the potential for oxygen in steelmaking. Seventy oxygen-blown converters (undreamed of 12 years before) were operating in 31 countries!

H. R. Morrison of the Linde Co. also tells us that the source of oxygen has seen some interesting changes. Whereas in the mid-1950's more than half the oxygen was made on the site by plants owned by the steel companies, this company-owned proportion will drop to 15% when the present large expansion in capacity is reached. Since it is desirable to avoid the cost of large gas holders, moderate storage facilities for liquid oxygen are provided at these on-site plants, and fluctuations in demand are satisfied by shipment of liquid oxygen by tank car or truck from other plants as far as 200 miles away. Since outside suppliers such as Linde are depended upon to provide this "fly-wheel" capacity, the steel companies now almost universally depend upon them to build and operate their on-site plants.

More on the Oxy-Fuel Lance

As pointed out in the preceding note, one of the most promising areas for using oxygen is in openhearth steelmaking. A few months ago Ford Motor Co. announced a new system for speeding the melting of openhearth heats (see Technical News in Brief, June 1960). A vital part of the system employed by Ford is the oxy-fuel lance which combines oxygen with natural gas to produce

a temperature of nearly 5000° F. at the nozzle.

In action, the lance looks and acts like a gigantic blowtorch. Lances in use now are delivering 40,000,000 Btu. per hr., and this figure is due to be raised appreciably in the near future. With such high rates of heat input, scrap charges can be melted very rapidly; refining is also speeded because oxygen can be injected by itself after meltdown is finished.

Because of the high temperatures reached, refractories may need some attention. For example, basic roofs are almost sure to be necessary in openhearths equipped with these lances. However, there is one factor which may offset the effect of the higher temperatures; the flame is directed toward the bath rather than being horizontal as it is in conventional openhearths. Thus, the hottest part of the flame is absorbed in heating the bath.

An interesting experiment now in the works at one mill may, if successful, result in a radical change in openhearth design. This plant is installing four lances in the roof of an openhearth with the idea that they can provide all the heat needed to melt a charge. If it works, neither the end burners nor the checkerwork (used in conventional furnaces to preheat the blast) will be needed. This can reduce the cost of new openhearths to an appreciable degree. However, the cost of the extra oxygen generating capacity must be considered too. Engineers of Air Products, Inc., Allentown, Pa., estimate that a 500-ton-per-day oxygen plant will be needed to supply one openhearth.

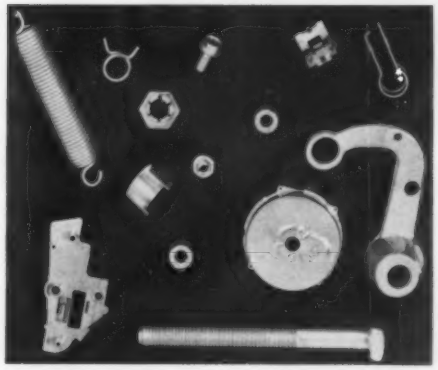
Whatever develops, the idea hatched with Steel Co. of Canada's experiment with oxygen in an openhearth 18 years ago is beginning to pay off. Cheap oxygen is bringing about a true revolution in steelmaking – one that seems likely to rival the introduction of electric furnaces.

Zinc Coatings Applied by Tumbling

New in the field of surface protection is a process which applies metal coatings to parts by tumbling them in a metal powder mixture. The new method, recently announced by Minnesota Mining and Mfg. Co., is being used to coat parts with zinc. Initial capital investment is low and the system can be operated at lower cost than other plating methods. Hydrogen embrittlement in high-strength steels is also avoided.

Necessary ingredients for applying the coatings include a specially prepared plating metal in powder form and two proprietary compounds. One of these is composed of particles of glass which consolidates and cold welds the metal powder into a dense, adherent coating (see photo).

Parts are first cleaned and then tumbled in a rubber-lined barrel for about 45 min. with water and measured amounts of the three powders. Thickness of the coating is controlled by the amount of metal powder in the mix. Although the system is limited to zinc, tests are underway on coatings of cadmium and other metals.



MECHANICALLY PLATED PARTS
Coating Is Applied by Tumbling in Wet Powder Mix

Up Trend in High-Alloy Castings Levels Off

Alloy Casting Institute's statistical Review for 1959 gives some interesting figures. Seemingly the proportion of tonnage going into heat resisting items (45%), corrosion resisting (45%) and abrasion resisting (10%) has remained about constant during the 1950 decade. Total production for 1959 (68 million pounds) is slightly less than the average for 1951, 1952, 1953, 1956 and 1957, which were the prosperous years for the industry. In other words, the long term upward trend in the 1946 to 1957 period seems to have been halted.

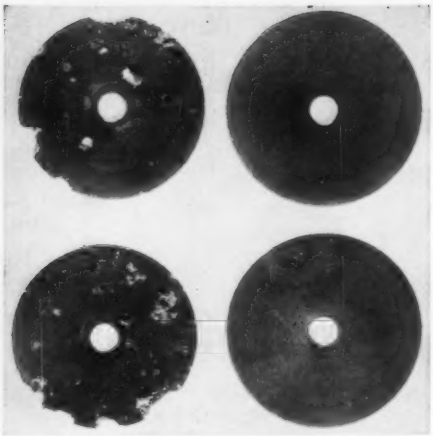
Perhaps this is due to the increase in price. Since 1944 the price of high-alloy castings – defined as those containing 8% or more of chromium, nickel, or both – has increased from $0.60 per lb. to $1.15 per lb., a steady rise of nearly 4¢ per year. Of the corrosion resisting analyses, the 19-9 Cr-Ni type alone now accounts for 70% of current production. It is made by 46 companies. Of the heat resistors, 33% are 25-12 Cr-Ni, and 22% are 35-15 Ni-Cr.

Palladium Slows Titanium Corrosion

As reported in *Metal Progress* (May 1959, p. 117), a small amount of palladium improves the corrosion resistance of titanium. This has been further confirmed by tests conducted at the Argonne National Laboratory and at Columbia-Southern Chemical Corp., Barberton, Ohio.

At Argonne, samples of titanium and 0.2% palladium-titanium were boiled in 5% sulphuric acid. The latter showed little corrosion after 170 days while unalloyed titanium corroded excessively in half the time. Also important is that the corrosion rate of the palladium-titanium alloy did not increase with exposure time.

At Columbia-Southern, specimens were placed in a stream of boiling, nonaerated calcium chloride (73%) for 84 days. This corrosive medium pitted



0.2% Palladium, Titanium Resists Attack
Alloy (Right) Fairs Better in Boiling Calcium Chloride Than Unalloyed Titanium

and perforated the unalloyed titanium but had no effect on the palladium-titanium alloy (see photo).

Materials Progress in Applications for Nonmetallics

A change to Delrin, an acetal resin produced by DuPont, has resulted in cost savings of 80% and a 16-fold increase in the life of an important component in a business machine made by Remington Rand. Formerly fabricated from beryllium copper, the part cost about $0.63. It is now made of Delrin by B & B Plastics, Oakville, Conn., by injection molding for about $0.12. With Delrin, the service life of the part, a small link which transmits an impulse from a punched card to circuits in a data processing machine, has increased from 5 to 80 million cycles. Links made of beryllium copper proved to be a source of metal particles which led to bearing failures in nearby parts. Additional properties of Delrin important in this application include its dimensional stability and ability to dampen vibrations.

Another example of the use of Delrin is in small pumps for windshield washers on 1960 Fords and Mercurys. Delmar Co. of Cookeville, Tenn., a maker of auto windshield washers, chose the thermoplastic for its gear-type vacuum-actuated pump which is driven off the fan belt. Aside from having the necessary toughness, strength and corrosion resistance, Delrin can be made economically by injection molding and is much lighter than metal die castings.

Potassium titanate, a fibrous inorganic material, is also a useful nonmetallic. Called Tipersul by DuPont, it is available in lumps, loose fibers, blocks, sheets and paper forms.

Useful up to 2200° F., Tipersul is a good insulator against heat, noise and electricity. It has low heat conductivity, low density and scatters infrared radiation. As an ablative material it can protect space vehicles from high temperatures for short periods. When added to fluorocarbon resins such as Teflon, potassium titanate promotes dimensional stability.

Welding Research Council Surveys Welding Problems

Welding is not the only metallurgical field which seems to be growing more rapidly than our knowledge about its fundamentals and its capabilities, but it is a good example of the truism that every new fact opens up two new avenues for inquiry. For example the Welding Research Council issued a bulletin listing about 170 current problems worthy of research. The suggestions come largely from engineers, scientists and executives in American industry and governmental agencies. No less than 51 of these apply to ten different welding processes. The rest are classified as follows: structural steels (14), plain and low-alloy steels (26), high alloys (5), residual stresses (20), pressure vessels and piping (11), general and unclassified (43).

From Here and There

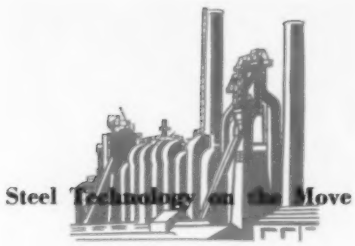
Southern California Edison's atomic reactor, to be generating 330,000 kw. of power by 1964, will have a vessel for the pressurized water 41 ft. high, 12 ft. diameter, 10 in. thick and weighing 300 tons! The primary loop will operate at 650° F. and 2150 psi. Westinghouse will design and build the equipment and Bechtel Corp. will be engineer-constructor. The plant will be wholly financed by the public utility, and it is expected to be "economically competitive with conventional plants over its lifetime".

• • • •

At a recent symposium on refractories, Norton Co. announced a new high-temperature material termed "Crystolon 63". Made of silicon carbide bonded with complex nitrides, this refractory is expected to be useful wherever strength, good thermal conductivity and corrosion resistance to fused salts are needed. One important application for the refractory is as a liner for aluminum refining cells (the material resists corrosion by molten aluminum and cryolite).

Report to Technical Management Updates Progress in Metals

Men in technical management, faced with increasing wages and higher-priced materials, must look to improved programs for cutting costs and improving efficiency. In next month's Metal Show issue, *Metal Progress* will present a special report designed to bring up to date the progress made in selecting and applying steels, high-temperature alloys, aluminum, copper and magnesium. Included is a comprehensive section on selection of modern steels, how to form them, best quenching practice and a new welding technique.



Residual Elements in Steelmaking

*By F. C. LANGENBERG and J. F. JOHNSON, JR.**

Small amounts of many elements – copper, tin, arsenic and lead, to name a few – remain in steel when refining is completed. Such "minor" elements can have a decided effect on the physical and mechanical properties of the metal. This article gives the sources and effects for many of these elements. (D11s)

FREQUENTLY REFERRED TO AS tramp elements, minor constituents, incidentals, or contaminants, residual elements are undesirable or unnecessary elements which remain in steel after refining is completed. These elements often have a definite effect on properties, and must be considered when a steel is being applied.

Also, at one time or another, every element – even carbon, silicon and manganese – is a residual in some application. However, such elements must be related to a specific product composition and use, because some of them may be beneficial to one product while detrimental to another. For example, copper is often deliberately added to improve atmospheric corrosion resistance of some steels. Yet it is commonly classed as a harmful residual. Very low cobalt contents were never considered harmful in stainless steels (and still are not), but now, certain nuclear applications limit Type 304 to no more than 0.01% cobalt.

Though most tramp elements come from raw materials (such as ore, pig iron, scrap and ferroalloys), refractories, fluxes and fuels can also contribute to contamination. Some of the more important residual elements which may come from ores (and from pig iron) are titanium, vanadium, chromium, molybdenum, arsenic, nickel, copper, zinc, lead, tin and cobalt. Scrap can also introduce all of these along with tungsten and antimony. Figure 1† illustrates the flow of minor elements in an integrated steel plant with openhearth (or electric) furnaces.

Trends in Residuals

Raw materials have been changing through the years; these changes have affected the residual content of steels. This is especially true of scrap. Although high-grade ore deposits are dwindling here (and beneficiated low-grade ores along with foreign imports are being used extensively), we anticipate no significant changes in tramp elements which originate in ores. (Figure 2 illustrates ore stockpiling.) Instead, better beneficiation and melting practices will keep them at the present level.

Scrap is another matter. In steelmaking,

*Manager of Process Research and Staff Metallurgist, respectively, Crucible Steel Co. of America, Pittsburgh. This article is based on a talk presented before the Birmingham Chapter.

†Taken from "Significance of Minor Elements in Iron-Bearing Raw Materials for Integrated Steel Plant", by C. B. Jacobs, J. F. Elliott and M. Tenenbaum, A.I.S.I. *Yearbook*, 1954, p. 123-150.

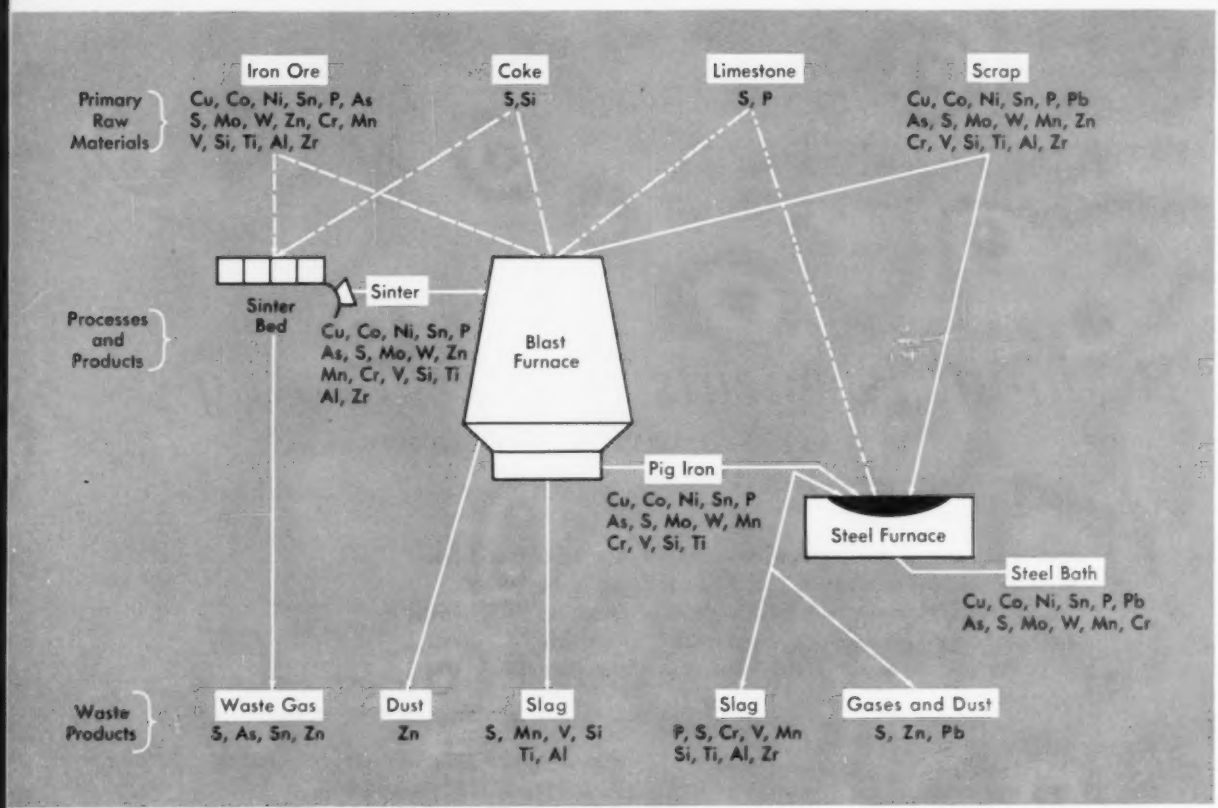


Fig.1 — Flow of Minor Elements in Steelmaking. This diagram applies to an integrated plant with openhearths or electric furnaces

alloy and nonferrous-contaminated scrap must be separated from carbon steel scrap. This is important because alloy steels are appearing in scrap more and more. There is also a trend toward larger charges of light scrap. More stamping and welding operations and a broadening market for lighter consumer goods have resulted in the accumulation of such light scrap.

The increased use of hydraulic-bundled scrap for melting stock has also led to an increase in residual elements. Although excellent for melting because of their density, such bundles increase the chances for contamination under even the most rigorous inspection programs. Bundled scrap, much of which is purchased, is used in both openhearth and electric furnaces (see Fig. 3). Contamination of heats by this type of scrap is more than a remote possibility; of all scrap used in steelmaking since 1956, about 15.6% consisted of bundles.

On the other hand, recent innovations in the steel industry indicate that more hot metal and less scrap will be used. Iron ore beneficiation and blast-furnace improvements are making more hot metal available, and the new steelmaking techniques require a higher percentage of hot metal. For example, the L-D converter requires a maximum of about 30% scrap at present, although the scrap charge may be increased to 50% if improved refractories appear. (Figure 4 illustrates an oxygen converter.) In openhearth practices, the increased use of oxygen roof jets favors increased amount of hot metal. With more hot metal being used, less scrap is needed; this will work against an increase in residual levels. However, the long-range trend is *toward* such an increase. This rise is expected because of greater production of alloy steels (where the tramps are often basic alloying elements), and the difficulties in complete scrap segregation.

How Residuals Affect Steel

In an integrated steel plant, products can range from almost pure iron to a broad variety of alloy steels. In addition, any given product may be subjected to hot working, cold working,

The Association of Iron & Steel Engineers is holding its biennial exposition the week of Sept. 27 in Cleveland. This meeting will feature exhibits demonstrating new ideas in steel plant equipment and maintenance. Among significant developments to be reported are: advanced practices in automatic steelmaking, oxygen processes, techniques for increasing blast furnace output, the first automatic rolling mill, a British oxygen steelmaking process, and a new technique for changing steel chemistry through operating practice. A report on Soviet ferrous metallurgy and a review of steelmaking practice in Japan and India are expected.

and heat treatment. Later, the iron and steel product may undergo still further fabrication. Depending on its future application and the processing to which it will be subjected, each product must exhibit certain properties.

These properties are expected to be produced by the proper amounts of the various alloying elements. Yet, the residuals can modify these desired properties to such an extent that the steel, even though it may contain the specified elements in the specified amounts, will not answer requirements.

Many of the effects of residual elements on the properties of iron and steel depend on the type of occurrence in the metal product. For example, such elements may be dissolved in the matrix or appear in carbides, nonmetallic inclusions or intermetallic compounds.

Copper – In dealing with each element separately, we will start with copper. As an alloying element, it increases hardenability moderately and raises the yield strength and tensile strength by precipitation hardening or solid-solution strengthening of ferrite. Copper is used extensively to improve the resistance of plain carbon and low-alloy steels to atmospheric corrosion; it is also used in cast steels.

Table I – Effect of Copper on Surface Cracking of 1070 Steel*

Cu	Average Penetration†	
	Forging at 2100° F.	Forging at 2200° F.
0.20%	0.007 mm.	0.055
0.40	0.194	0.200
0.60	0.276	0.351
0.80	0.366	0.401

*From "Alloys of Iron and Copper", by J. L. Gregg and B. N. Daniloff, McGraw-Hill Book Co., New York, 1934.

†Average penetration of cracks that occurred when forging 3.5-in. octagonal bars to 1-in. diameter rounds.

Fig. 2 – Stockpiling Iron Ore at Steel Plant. Residual elements in ore cause little difficulty. (Courtesy Blaw-Knox Co.)

Although copper can increase mechanical properties, it is detrimental and a "tramp" when a highly deformable steel is desired. Copper also reduces the deep drawability of steel sheet, but the critical copper content (below which it has no adverse effect) is not known. Statistical analysis of mill data indicates that the critical level is very low. In some steels, copper, when over 0.20%, has a bad effect on hot forming properties. When rolled or forged above 2000° F., such a steel will crack, sometimes quite badly. This be-

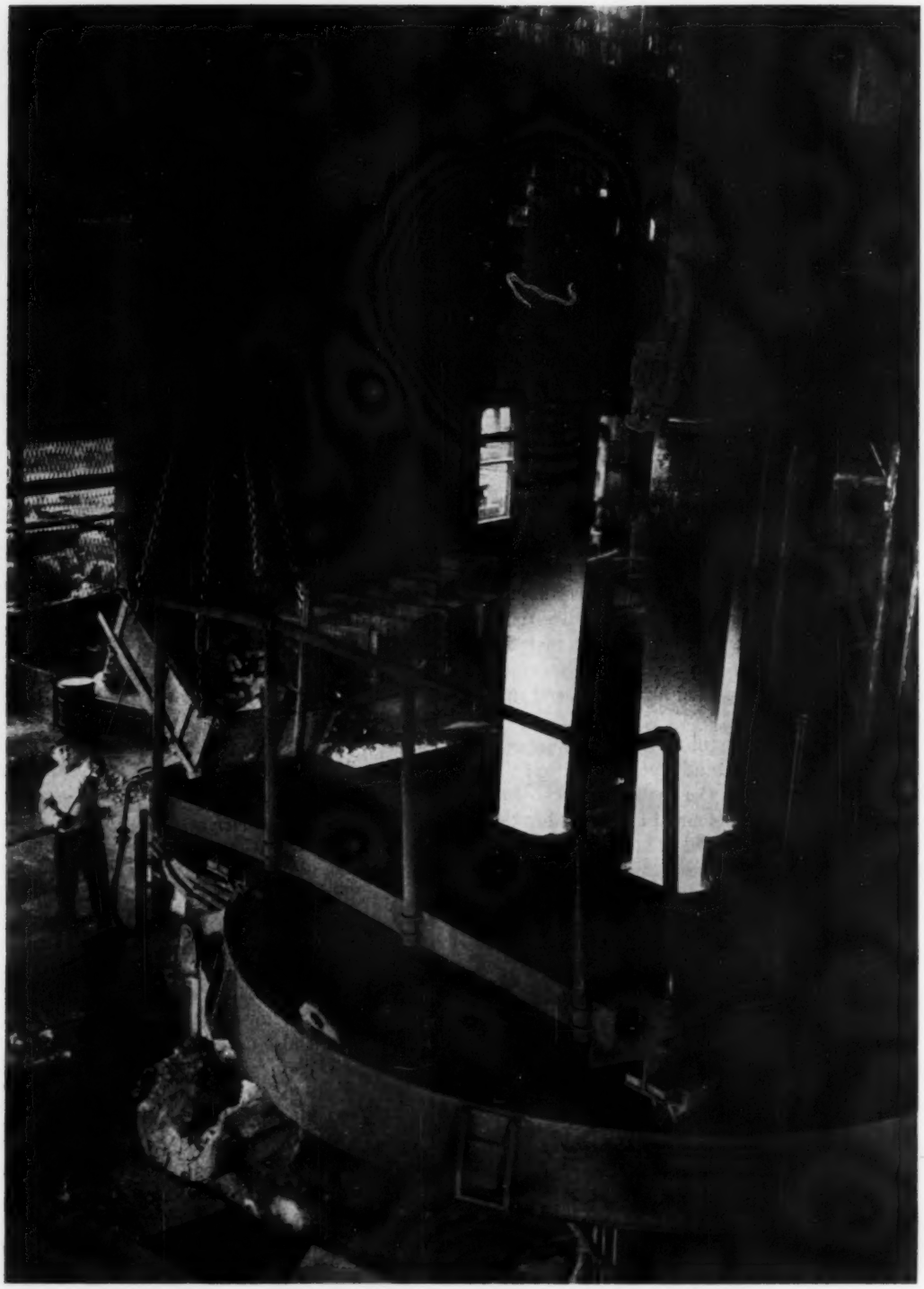


Fig. 3 – Electric Furnace Receiving Addition of Ferrochromium. Because these furnaces use a high percentage of scrap, the steel made in them can have a high residual content. Scrap must be carefully selected if residuals are to be kept within limits

Fig. 4 – An Oxygen Converter in Action. Since such converters use more hot metal and less scrap than openhearths and electric furnaces, the resulting steel is less likely to be troubled by residual elements. (Courtesy Pennsylvania Engineering Corp.)

havior may be due to preferential oxidation of the iron and the formation of a copper-rich alloy with a lower melting point which may become molten and penetrate intergranularly.

Experiments have been conducted to determine the effect of copper on surface cracking during forging, and Table I illustrates some of the findings. This surface fissuring is one reason copper has not been used more extensively as an alloying element, even though it produces other favorable properties.

Lead, Zinc and Tin – Lead and zinc have high vapor pressures at steelmaking temperatures. When lead is a tramp, it is present only in small amounts because it usually vaporizes from the molten steel bath. However, because of lead's high density and fluidity at elevated temperatures, it has an additional detrimental effect in that it can penetrate furnace bottoms.

In stainless steel, lead has been found along the primary grain boundaries and between the dendrites. It is undesirable in austenitic stainless steels because it has a bad effect on hot workability. According to Bergh*, more than 0.005% lead in 18-8 stainless steels will cause edge cracks in the ingots. Cracks may also develop during forging or rolling because of high mechanical stresses and the presence of lead at the primary grain boundaries. Because it must be liquid at the hot rolling temperatures, lead weakens the cohesion of the steel. Ferritic-type stainless steels are not appreciably affected by the small amounts of lead which cause trouble in the austenitic types.

Little is known of the occurence or effect of zinc in electric furnace or openhearth steels. Because that element has a high vapor pressure, it boils off at steelmaking temperatures. However, zinc could be very harmful to a blast furnace since it may condense inside the furnace shell, eventually rupturing it. Also, zinc harms

*"Influence of Lead on Behavior of Stainless Steel", by S. Bergh, *Iron Age*, Vol. 164, July 14, 1949, p. 96-99.

openhearth furnaces by clogging the checkers when its oxide solidifies after vaporizing.

Tin is soluble in all steels, whether they are liquid or solid. Thus, when present, residual amounts of tin are usually in solid solution. The element increases strength and decreases ductility of many plain carbon and low-alloy steels. The intensity of these effects depends on grade, tin content, and heat treatment.

Though there is general agreement that tin reduces hot workability, researchers disagree concerning the amounts which will cause trouble. Laboratory investigations with small ingots seem to indicate a higher tolerable level of tin than do statistical studies of mill data.

Though little is known regarding the effect of tin on the hot workability of stainless steel, the element is a strong ferrite-former. Thus, it may cause poor hot workability of austenitic stainless steels that have compositions on the borderline of austenite-ferrite fields. (Duplex structures of austenite and ferrite usually result in poor hot workability.)

At Crucible, we have established (by statistics) that small amounts of residual tin are detrimental to the surface quality of stainless sheet. Close inspection and tight specifications on charge materials are needed to keep tin below this critical limit.

Arsenic, Antimony, Tungsten and Molybdenum — All of these elements are almost completely recovered in conventional steelmaking processes. Arsenic and antimony, particularly the latter, increase susceptibility to temper embrittlement, especially in chromium and chromium-nickel steels. Segregating much like phosphorus in low-carbon steels, arsenic is difficult to homogenize by heat treatment. Steelmen generally concede that both arsenic and antimony reduce ductility and impact strength, and may lead to surface cracking. At higher strength levels, the effect of these elements on lowering the impact properties is greater.

Tungsten and molybdenum* exert a hardening effect on steel, lower the ductility, and can cause difficulty in deep drawing steels if present in sufficient amounts. Also, these are ferrite-forming elements, and can decrease the hot workability of austenitic stainless steel by forming a duplex structure. However, the latter effect would require more tungsten or molybdenum than is normally considered "tramp".

Cobalt, Titanium and Vanadium — As a tramp element, cobalt has very little effect on the properties of iron and steel. Though it decreases the hardenability of steel, its effect is so slight as to be negligible. Apparently, the only known application in which cobalt produces an undesirable effect is in stainless steel for use in or around nuclear reactors (see Fig. 5). When cobalt is present in austenitic stainless steel subject to neutron absorption, the element may be converted to cobalt-60, the dangerous, long-lived isotope. Therefore, some nuclear applications for Type 304 stainless specify 0.01% maximum cobalt.

Also, in spectroscopic analysis cobalt and nickel have similar responses. As a consequence, cobalt must be determined apart from nickel if truly accurate analyses are needed.

Titanium and vanadium are present to a very minor extent in openhearth steels because they oxidize readily and can be easily slagged off. Both elements form carbides and nitrides which are likely to appear in the product as nonmetallic inclusions. In some electric furnace steels, titanium carbo-nitrides have been identified.

To summarize briefly, copper, tin, arsenic and antimony are substintially recovered in all iron and steel, and are usually detrimental. Molybdenum is completely recovered, but is not generally considered to be very harmful though it adds to the hardenability. Tungsten, titanium and vanadium are detrimental only to certain types of iron and steel, and do not often occur in substantial amounts unless purposely added. Lead and zinc occur in very small quantities in a finished product as residuals, but because of their high vapor pressure may harm the melting furnace.

Removing Copper and Tin

Concerning copper removal, a comprehensive investigation by Langenberg and Lindsay has shown that the copper content of steel melts

*EDITOR'S NOTE: Residual elements also affect hardenability, a fact not generally realized. For example, steelmakers have occasionally been troubled by unexpected and excessive hardenabilities in some carbon steels. Because of the increased depth of hardness imparted by the combined effect of such residuals as chromium, nickel and molybdenum, certain parts made from these steels would harden more deeply than would be expected from the reported analysis. In such instances a complete analysis will tell the full story.

Recently, the automobile manufacturers have been taking advantage of this feature. For example, by ordering plain carbon steels — 1045, for example — with a specified residual content, they have been getting the equivalent of a low-alloy steel at the price of a plain carbon steel.

Fig. 5 — Stainless Steel Reactor Vessel. In steels for applications in the atomic energy field, residual cobalt must be kept to very low values. When exposed to irradiation, the element can be converted to the dangerous, long-lived isotope, Co^{60}. (Courtesy Blaw-Knox Co.)

can be lowered by two distinct methods*. If the initial copper content of an Fe-Cu-C melt is fairly high and the carbon content exceeds 0.03%, there is a separation into two liquid phases, one phase rich in iron and the other rich in copper. The solubility of copper in the iron-rich phase decreases with decreasing temperature, and separation using this immiscibility should be performed at the lowest practical temperature.

Copper can also be removed by treating melts with lead or sodium sulphide slags. Lead has obvious practical limitations, but the sodium sulphide slags are quite effective at temperatures below 2550° F. In general, the method used to remove copper would depend on initial copper content, desired final copper content, refractory problems, and treatment limitations. Of course, it is obviously necessary to consider basic economic factors such as equipment costs, maintenance costs, plus availability and cost of the raw materials for treatment of the melt.

Conventional steel refining processes will not lower the tin content of steel. Even though tin has a very low melting point (450° F.), its boiling point is high (4100° F.) and its vapor pressure at steelmaking temperatures is fairly low. Thus, tin will not normally boil out of a steel bath. Nor is tin readily oxidized, and so it cannot be slagged off as tin oxide.

During the nickel shortage several years ago, it was occasionally hard to get high-quality stainless steel scrap which was essentially free of tin. As a result, some of the difficulties in processing stainless steel coils were attributed to a high tin content. To make this high-tin scrap usable, Crucible began to investigate methods for removing this unwanted element. Research metallurgists tried treatment with halogens, vaporizing during a carbon boil, and formation of a zirconium-tin compound which would slag off. Rare earths, magnesium and lead were also used as reagents.

Though none of the methods were successful in reducing the tin in chromium-nickel stainless steels, tin content of 1% C melts was low-

*"The Removal of Copper From Iron-Copper-Carbon Melts", by F. C. Langenberg and R. W. Lindsay, Contributions to the Metallurgy of Steel, No. 51, A.I.S.I., New York, March 1957.

ered when oxygen was blown or when lead was added. The slight reduction in tin content (from 0.075 to 0.055%) due to oxygen blowing may be attributed to the high temperature attained when oxygen is injected. Also, the flushing action of carbon monoxide enables tin to escape as a vapor. Thus, some tin may be removed in the oxygen processes (such as the L-D converter), and questionable scrap should be charged with the hot metal prior to blow.

Lead was effective in removing tin. However, since a 1:2 ratio of lead to iron is needed, the process is expensive and impractical. As the situation stands today, there is no practical method for removing tin from the bath. Consequently, the best system for controlling tin levels is to keep it from getting in. In other words, make sure that there is no tin in the scrap. Fortunately, there are many chemical processes for treating tin cans or tin-coated scrap; however, these are beyond the scope of this paper.

Table II – Properties of Some Important Residual Elements

Element	Melting Point	Boiling Point	Vapor Pressure at 2912° F.
Cu	1981° F.	4237° F.	1.03 mm. Hg
Sn	450	4100	1
Pb	621	2948	400
As*	1139	—	> 760
Zn	786	1665	> 760
Co	2723	5252	0.0097
Ni	2651	4946	0.009
Mo	4748	8672	8×10^{-7}
Sb	1168	2516	760
Mn	2300	3452	25
Cr	3434	4532	1.55
Al	1220	4442	16.7

*Sublimes.

Effect of Vacuum Melting

Occasionally, references have appeared concerning the effect of vacuum processing on residuals in liquid alloys. The most complete summary is the work of Gill and co-workers* from which most of the following information was taken.

Table II lists the melting point, boiling point and vapor pressure (of the element at 2912° F.) of some common residual elements. Even though vapor pressures will be much less when the elements are in dilute solution, it does appear that the content of several of the residuals could be lowered by vacuum melting. Time, temperature and vacuum melting technique employed will be important.

Time under vacuum has a great effect on the residual content of iron-base binary alloys. In work done in a vacuum fusion gas analysis apparatus (where the pressure was 1 micron and the temperature was 2912° F.), manganese, lead, copper, tin and zinc boiled from the melt quite rapidly, as predicted by Table II. Conversely, chromium and silicon dropped slightly, while nickel and phosphorus were virtually unaffected. When a series of commercial steels was vacuum melted (by induction at 1 micron, and arc at 4 microns), the change in residual content agreed with the trends observed in the binary alloys. Copper, tin, lead and manganese were almost completely eliminated by the vacuum-induction treatment. Melting by the consumable-arc method produced a similar lowering, but not nearly to the same level as induction melting. In vacuum-arc melting, the metal is liquid for a much shorter time, so that residuals have much less opportunity to escape as vapors. We can conclude, however, that the large-scale vacuum degassing processes (such as ladle degassing, stream degassing into a mold or ladle, or vacuum lifter processes) will also lower the volatile residuals depending on pressure and time of exposure of the liquid metal to the vacuum.

In conclusion, it should be obvious that it is very difficult to remove residuals from steel economically. This emphasizes the importance of careful control and selection of raw materials used in the steel making process. At Crucible† all important raw materials are purchased according to written specifications. These specifications require, among other items, that the chemical composition of the material conform to certain limits. Furthermore, all important residuals must be below certain critical values. It is through such methods of selection and control of raw materials that the steel industry can defeat the problem of rising "tramp" levels.

*"The Behavior of Various Elements in Vacuum Steelmaking", by G. M. Gill, E. Ineson and G. W. Austin, *Journal* of the Iron and Steel Institute, Vol. 191, Part 2, February 1959, p. 172-175.

†Other steel companies also order raw materials to specifications.

Steel Technology on the Move

Revealing Lead Inclusions in Leaded Steels

*By GLADYS M. CHALFANT**

A new metallographic procedure permits direct microscopic observation and identification of lead inclusions in leaded carbon, alloy and resulphurized steels. The method includes final polishing with an aqueous suspension of gamma alumina that is precisely neutral (pH-7). (M20; AY, *Pb*, 9-69)

FOR SEVERAL YEARS, lead has been added to steel to improve its machinability. However, for the metal to be fully effective, it should be uniformly dispersed. Up until now, though, there has been no sure method for studying the size, shape, and distribution of lead particles in the steel. Because most metallographic polishing and etching procedures have failed to retain the inclusions of soft lead, this element has been repeatedly reported to be present as a submicroscopic dispersion in the steel.

To contradict this opinion, however, microradiographic techniques showed that the lead occurred in fairly large particles. These particles were associated with the manganese sulphide inclusions in a resulphurized steel, and as elongated particles or stringers in the matrix of a nonresulphurized steel.

Though these microradiographic techniques were useful, samples were difficult to prepare. Furthermore, most plants lacked the needed X-ray equipment. All in all, a better method for revealing lead inclusions was needed.

To fill this gap, we have devised a simple, direct metallographic procedure that permits the lead inclusions in steel to be positively identified with any light microscope. Three definite steps must be followed rigorously to maintain the lead inclusions in place. First, a longitudinal section of the billet or bar is obtained for examination. During all the cutting operations, specimens should be flooded with a coolant, usually water. They are then ground on a wet belt grinder, No. 180, 240 and 320-grit belts being used in succession. If a dry grinder is used, the specimen should be frequently cooled in water, and should be held very lightly on the belt.

Intermediate grinding is done on a horizontal wheel covered with a silicon carbide disk. The wheel is rotated at 550 rpm. and is flooded with water during the grinding operation. After being ground successively on No. 320, 400 A, 500 A and 600 A-grit disks, the specimen is rubbed on a 3/0-grit emery paper embedded

*Assistant Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

Fig. 1 — Steelmakers Make Leaded Steel. As molten steel pours from the ladle into an ingot mold, a pressure gun sprays tiny lead pellets into the flow. The operation is timed with a stopwatch, and hoods over each mold protect workers from lead fumes

with graphite. This fine grinding is complete when the surface of the specimen shows nothing more than very fine uniform scratches.

Preliminary Polishing

When grinding is finished, the specimens are polished on a wheel (550 rpm.) covered with a billiard cloth which has been soaked in an aqueous suspension of Linde "B" compound (trade-name for gamma alumina). Holding the specimen with scratches parallel to the direction of wheel rotation, the metallographer applies medium pressure to the specimen as he moves it from the center to the periphery of the spinning wheel. After the scratches have been removed, he reduces the pressure, and rotates the specimen around the wheel in a direction opposite to that of the wheel's rotation. During the final part of this operation, the billiard cloth should be kept very wet with frequent additions of distilled water. The total time for this polishing operation should not exceed 3 min.

If the surface of a leaded steel has been

rough-polished correctly, the lead appears as black mottled areas (Fig. 2). However, if voids are present (instead of the indicated black mottled areas), grinding and rough polishing must be repeated before the final operation.

Final Polishing

The final polishing is done on a nonrotating wheel covered with a "Microcloth" which is saturated with a weak solution of gamma alumina* that has a pH of *exactly* 7. As the specimen is moved over the cloth with a circular motion, it should just touch the cloth, and should be polished for as short a time as possible (40 to 50 rotations should suffice). The polished surface is then swabbed with cotton (saturated with 180 proof ethyl alcohol) until the surface is absolutely clean. Finally, the clean surface is sprayed with the same liquid and dried in a hot air blast.

After the specimen has been given the final polish with the solution of gamma alumina, the lead inclusions will appear as shown in Fig. 3. They are now off-white areas, with black boundaries that are distinct; such inclusions could not possibly be confused with any other phases present in the leaded steel. The manganese sulphide inclusions have a clean (gray) appearance, with definite lines of demarcation that delineate them from the lead inclusions and the matrix. An important advantage: This method reveals the lead as metallic lead particles in their original site and association, rather than as precipitated lead compounds. Furthermore, this new procedure is rapid, and the results are consistently reproducible.

Figures 2 and 3 show the lead inclusions in a leaded resulphurized steel in which the lead occurs predominantly as partial envelopes around the manganese sulphide inclusions. Equally consistent results can be obtained when the procedure is used to reveal lead inclusions in leaded, nonresulphurized carbon or alloy steels; in these, the lead occurs as unassociated lead inclusions or stringers in the matrix.

Fig. 2 – Manganese Sulphide (Gray) and Lead (Mottled Black) Inclusions in a Leaded Resulphurized Steel After Rough Polishing. Unetched, 500 ×

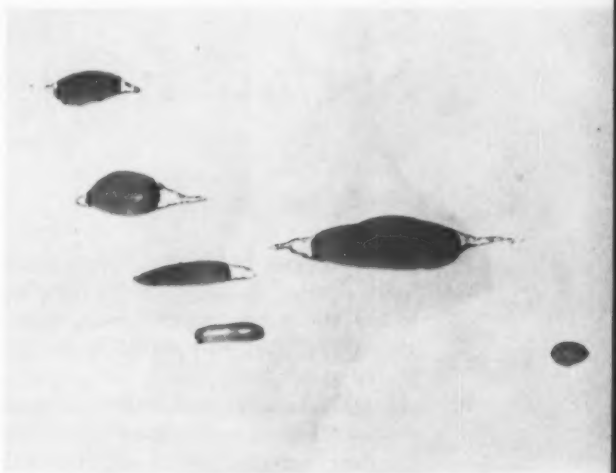


Fig. 3 – Manganese Sulphide (Gray) and Lead (Off-White) Inclusions in a Leaded Resulphurized Steel After Final Wet Polishing. Same area as Fig. 2

*Freshly prepared, pH-controlled, polishing compound of gamma alumina was used. The method for preparing it was developed by Rowland (see "The Metallography of Galvanized Sheet Steel Using a Specially Prepared Polishing Medium With Controlled pH", by D. H. Rowland and O. E. Romig, *Transactions*, Vol. 31, 1943, p. 980). Commercially pure, dry aluminum ammonium sulphate is roasted in an electric resistance furnace between 1800 and 1900° F. for about 5 to 6 hr. (or until all the sulphate is decomposed). After cooling, the gamma alumina powder is made into a paste with distilled water and passed through a 200-mesh sieve. The sieved product is diluted with about 40 to 50 parts of distilled water. The required pH of exactly 7, as determined by a pH meter, is obtained by adding a few drops of a very dilute aqueous solution of triethanol amine (0.1 g. per 200 ml. of distilled water) to the basic gamma alumina suspension.

Steel Technology on the Move

Surface Films on Annealed Stainless

*By J. H. WAXWEILER**

ACCORDING TO THEORY, bright annealing is fairly simple. Stainless steel is merely heated to the annealing temperature in a protective atmosphere; then it is cooled while remaining in that atmosphere.

Bright annealing not only is desirable but necessary for the manufacture of very thin stainless strip, sometimes called foil. Otherwise, the foil would have to be pickled (to remove the oxide scale) as a final step, and it would be next to impossible to control either thickness or surface on foil which is only 0.001 to 0.005 in. thick. Though both hydrogen and dissociated ammonia have been used successfully as protective atmospheres, the latter cannot be used with either Armco 17-7 PH or PH 15-7 Mo stainless because both may be nitrided by this atmosphere. This is undesirable.

When bright annealing is done in hydrogen with a dew point of −25° F. or higher, the resulting stainless strip has a definite blue appearance, and visual inspection is enough to distinguish it from strip which has been bright annealed properly. This observation led to an investigation aimed at learning how the color characteristics of the surface varied as the dew point was changed in small increments.

For the experiments, we equipped a laboratory furnace with a muffle and a coiler which could accommodate foil 0.0015 in. thick. When they were ready, we obtained 17-7 PH strip (representing two heats) in the cold reduced condition, and began testing. After heating the muffle to 1950° F., it was supplied with a hydrogen atmosphere. We varied the dew point by mixing hydrogen from two sources: regular bottle hydrogen with a dew point of −30° F. and dried hydrogen with a dew point less than −85° F. Several feet of strip were annealed at several dew points between these two limits. These strips were then examined visually; results are given below.

No.	DEW POINT	APPEARANCE
1	−85° F.	Bright
2	−56	Bright
3	−46	Bright to slightly milky
4	−41	Milky
5	−36	Bluish cast
6	−30	Bluer than −36° F. test

Differences in color were easily discernible when two different strips were placed side by side under a suitable light. However, when the two strips being compared were separated by only a few feet, it was difficult to determine which was brighter. Since we needed a more sensitive method to evaluate these strips, we decided to employ a spectrophotometer.

Coupons of each of these specimens were then tested, both color and reflectivity being recorded in quantitative values. (Color was measured by trichromatic coefficients and reflectivity by tristimulus values.) These coefficients can be used to compare two specimens,

*Senior Research Engineer, Research Laboratories, Armco Steel Corp., Middletown, Ohio. The author wishes to thank O. H. Fritzsche, spectrochemist at Armco Research Laboratories, and Frank Darby, Convair Div., General Dynamics, for their help.

Steels

When stainless steels are bright annealed in hydrogen, the color of the surface film darkens as the dew point of the gas rises. Spectrophotometer and X-ray diffraction tests show that increasing amounts of chromium oxide in the film are responsible. (J23a; SS, 14-62)

or, as in Fig. 1, to locate specimens on a plot. The central point of such a plot is white (or an arbitrary white standard), while the various hues or colors all lie in different directions from this point. The degree of saturation or hue of a specimen is determined by its distance from the center toward any particular color.

To ease plotting, the brightest sample of the group was arbitrarily called the "white" sample. Then all other specimens were located relative to this specimen.

We constructed Fig. 1 by using these numerical coefficients to locate the various points. Two continuity lines, each representing one heat, were then drawn. To read the chart, one starts at the brightest specimen (at the center)

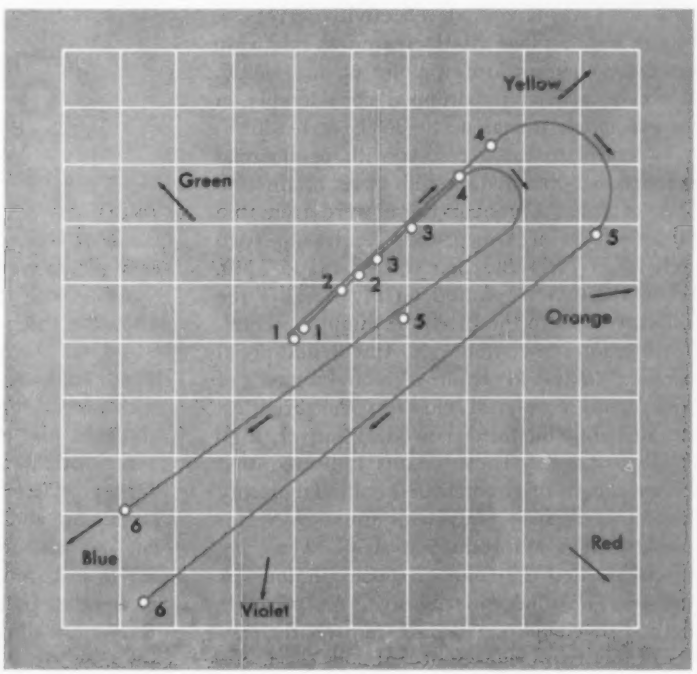


Fig. 1 — Effect of Dew Point on Color of Bright Annealed 17-7 PH Stainless Steel. Each number represents a different specimen of experimental strip, and each line represents a separate heat

and proceeds through increasing dew points to the darkest specimen. Each number denotes a separate strip specimen.

Color Varies With Dew Point

As the dew point was raised from −85° F. to −41° F., only one change in surface color was observed. The film became more yellow with the increasing dew point within this range, the hue or purity of the yellow being the same for both heats. However, as the dew point was then increased in successive steps to −36° F. and −30° F. the surface films changed color by first adding a small amount of red and then greatly increasing in blue. The two different heats were similar in their progress toward blue, but differed slightly in the amount of displacement toward red.

Earlier, we had observed that the cold reduced strip from the two heats differed slightly in brightness and surface density. Since these differences existed before annealing, we concluded that, at dew points above −41° F., the surface film became bluer with increasing dew points. But the final color also contained some red, the amount of red being influenced by the surface conditions *already present* on the strip before the anneal.

Reflectivity tests told a story quite similar to the color tests, the highest reflectivity value being obtained on the whitest sample. As the dew point was increased, reflectivity decreased. Figure 2 shows that this decrease was relatively small for changes in dew point up to −41° F. However, reflectivity dropped considerably in the specimens annealed at −36° F. and −30° F.

To correlate these results with commercial practice, we obtained samples of six production coils of foil. Three of these were from the Butler Works of Armco; they represented two coils of 17-7 PH and one coil of PH 15-7 Mo. When these were plotted on Fig. 1, all three fell very close to the brightest sample in color. Furthermore, two out of three additional samples (obtained from a manufacturer of honeycomb core) fell close to the brightest sample, while the third showed a relatively high yellow content. These results indicated that the specimens bright annealed in the laboratory developed surface films with the same color characteristics as production strip. Thus, we concluded that the color or spectrophotometer test was a quick, inexpensive, reproducible method of comparing surface film characteristics of any two bright annealed coils.

What constituents are present in these surface films developed by bright annealing? For that matter, how do they differ from the constituents present on an acid pickled surface? For answers we turned to electron diffraction studies of the surface. (Initially we had hoped to measure the actual thickness of these films by the electron diffraction pattern, but this, we found, was not possible.)

First, we studied electron diffraction patterns of the films from the specimens annealed in the laboratory, and identified the constituents as aluminum and chromium oxides in different

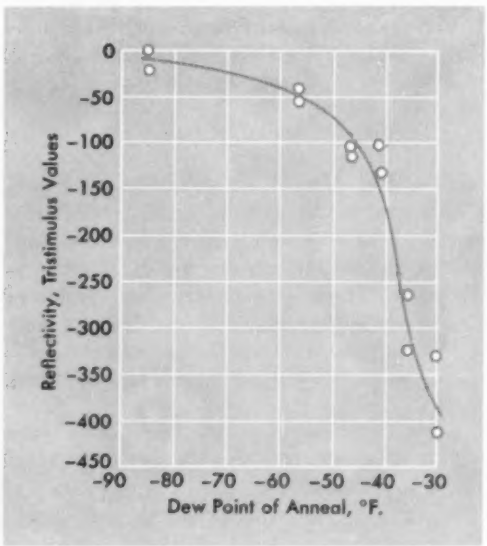


Fig. 2 – Effect of Dew Point on Reflectivity as Measured by Spectrophotometer

combinations. Though differences arising from dew points were not defined as exactly as was possible with the color tests, we were able to establish three different groups of specimens based on the patterns of their surface films. These are listed and described in Table I, along with a fourth group which describes the pattern obtained on the original cold reduced foil before bright annealing.

Judging from the data, a surface film of aluminum and chromium oxides was present on the specimen that was bright annealed at the lowest dew point that we could achieve. As the dew point was increased, the amount of chromium oxide relative to the amount of aluminum oxide increased until the latter con-

stituent could no longer be identified in the surface film (dew point, −30° F.). Probably it was masked out by the much larger quantity of chromium oxide.

When electron diffraction data were correlated with color data, all specimens that had a yellow color were also placed in Group 1 of the electron diffraction separation. Groups 2 and 3 include the specimens that caused the color continuity line to swing around toward red and blue.

The six production coils of foil were also tested by electron diffraction; all six were placed in Group 1. Thus, the electron diffraction results agreed with the color tests.

Some other aspects of these films could also be studied by electron diffraction. For instance, one of the strips annealed at −85° F. dew point in the laboratory was tested immediately in the electron diffraction machine. Then, after leaving the specimen uncovered in a room for several months, it was again tested. The two patterns were identical, indicating that the surface film produced on 17-7 PH stainless strip by bright annealing did not change when exposed to an interior atmosphere.

Other strips of 17-7 PH stainless steel (representing different dew points) were pickled before running electron diffraction patterns. (Strips were pickled in nitric-hydrofluoric acid, rinsed in water, and dried in air.) As expected, this operation changed the surface appearance. Again, the patterns indicated combinations of aluminum and chromium oxides which were indistinguishable from those of the bright annealed specimens of the first group tested in Table I. Undoubtedly, pickling removed all surface films, but once out of the bath, the stainless steel developed a new film. Though this phenomenon has been explored and reported many times before, we were interested to learn that the newly formed film was similar to the surface film formed during bright annealing at very low dew points.

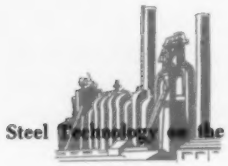
Table I — Grouping of Bright Annealed Strips

Group	Composition of Surface film	Specimens in the Group
1	Aluminum oxide Al_2O_3, and chromic oxide Cr_2O_3 (cubic) or chromium iron oxide $Cr_2O_3 \cdot FeO$, or both	All specimens of both heats annealed at dew points of −85, −56, −46 and −41°F.
2	Chromic oxide Cr_2O_3 (cubic), chromic oxide Cr_2O_3 (hexagonal), alumium oxide Al_2O_3 (less prominent)	Specimens of both heats annealed at dew point of −36° F.
3	Chromic oxide Cr_2O_3 (cubic)	Specimens of both heats annealed at dew point of −30° F.
4	Amorphous type pattern; not identifiable	Cold reduced strip of both heats

Production Quality Control

Bright annealing 17-7 PH foil in the laboratory enabled us to exercise great care and control of the many variables associated with this operation. For this reason, we feel that variations in color and electron diffraction patterns were truly due to differences in dew point. Furnaces for bright annealing on a production basis are more difficult to control. The dew point of the incoming protective gas can be determined accurately, but there are many sources of air or oxygen infiltration. Leaks in the gas line between the point where the dew point is measured and actual entry into the furnace, leaky furnace seals where the strip enters and exits, leaky furnace seals around roller bearings or other moving parts, cracks and weld breaks in the muffle or the bellows joining two muffle tubes, and oxides on the surface of the entering strip are but a few of them. By itself, definition of dew point of the hydrogen as it enters is not enough to insure production of highest quality strip.

However, this study indicates that the surface quality of bright annealed strip can be measured quantitatively by the spectrophotometer, and that strip bright annealed in production is equivalent to strip annealed at very low dew points in the laboratory muffle.



Steel Technology on the Move

Silicon Irons up to Date

By WESTON MORRILL*

In the past decade, crystal-textured material has become widely available, and cube-textured steel is in the wings. Improved instrumentation and better analytical techniques have aided the fundamental research needed for these developments. (A-general, M26c, P16; Fe-b, *Si*)

TWELVE YEARS AGO *Metal Progress*† published a brief summary of some 15 years of technical progress which resulted in the commercial production of crystal-oriented silicon irons for electrical equipment. That article hinted that further developments in the same field were sure to follow. Since then, there have indeed been many significant new developments.

The more spectacular advances have been made in the crystal-oriented silicon irons, although the whole field has benefited from a concentrated research and development effort. In this work chemistry, physics, metallurgy, ceramics, and engineering have all contributed.

Grain-oriented, anisotropic silicon iron is a crystal-textured material, having a cube-edge direction of the basic iron lattice lying parallel to the long, or rolling, direction of the strip, and a cube-face-diagonal plane in the plane of the strip, in other words, a (110) [001] texture. Such a texture is developed by secondary crystal growth, controlled through selective actions of impurities at critical annealing temperatures, as well as by the basic matrix texture.

For textured, secondary crystal growth to occur in silicon iron, a number of critical conditions must exist. A strong (110) [001] secondary texture requires, first, a definite (110) [001] component in the primary recrystallized matrix. This component must exist as a crystal entity with a growth energy advantage over its variously oriented neighbors. Such an advantage might be attained by the distinctively large size of a properly textured grain, or by the adjacent positioning of similarly textured grains.

During the final heat treatment, certain properly dispersed impurities play a dominant role in textured secondary crystal growth. These impurities apparently function at or adjacent to a grain boundary to allow the growth of the few favorably oriented nuclei, while inhibiting the growth of the great mass of the matrix. Naturally occurring sulphides have been identified as one such impurity. Also, nitrides, either alone or in combination with other impurities, may be utilized in generating a preferred crystal orientation. It is quite probable that other similar interstitial impurities will stimulate textured crystal growth.

Since favorable magnetic characteristics are essential, these impurities must be removed from the silicon iron after they have accomplished their grain-growth function. This is done during the latter stages of the heat treatment, through solid diffusion and surface reaction control. Improvements in the melting and refining stages of steel manufacture, in hot processing and in heat treatments have all helped to control impurities.

Along with this impurity control, better knowledge of mechanisms (crystal growth and chemical purification) has aided improvement of commercial annealing cycles. For example,

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†"Improved Silicon Irons for Electrical Equipment", by Weston Morrill, *Metal Progress*, November 1948, p. 675.

Table 1 – Reported Properties of Anisotropic Silicon Irons

	Along Strip		Across Strip	
	Single Textured	Cube Textured	Single Textured	Cube Textured
Maximum permeability ($\mu_{max.}$)	65,000	100,000	8,000	65,000
Coercive force (H_c), oersteds	0.08	0.07	0.27	0.08
Residual induction (B_r), gausses	15,000	12,200	1,800	11,500
Gausses at 2 oersteds	16,300	16,600	11,000	16,000
Gausses at 10 oersteds	17,700	17,000	13,500	—
Watt losses at 60 cycles 15,000 gausses, 0.012 in. (watts per lb.)	0.60	0.56	1.60	0.65

a two-stage final anneal can improve the magnetic orientation. In the low-temperature stage of such an anneal, the best-oriented grains have ample time to nucleate and initiate growth. In the high-temperature stage, the preferred crystal growth is completed, all remaining crystallites are absorbed, chemical purification occurs, and internal strain is completely relieved. All of these processing improvements have resulted in higher usable inductions, lower coercive forces, better uniformity, and improved energy losses under alternating excitation.

Annealing of crystal-oriented silicon iron in a magnetic field results in improved magnetic characteristics through realignment of magnetic domain boundaries. Much work has been reported relating energy losses to domain wall motions.

There is much evidence that preferred crystal orientation may be induced by activation energies other than those associated with grain-boundary energy and chemical solution. For example, if a properly prepared, recrystallized silicon iron is strained within narrow limits, a crystal texture will develop upon proper heat treatment. Single crystals and highly anisotropic, multicrystalline aggregates, both in sheet form, when cold deformed in certain characteristic directions, form a typical fibrous matrix of mixed textures. When this matrix recrystallizes (with minor grain growth), the resulting texture is quite similar to that of the starting material. This process has become the basis for commercial production of thin-gage, highly oriented, silicon-iron strip.

Cube Texture

The flurry of announcements in late 1957 of cube-textured silicon iron, made originally in this country by General Electric Co., indicates that still other mechanisms for stimulating oriented crystal development have been discovered. Cube texture, (100) [001], provides two good magnetic directions in the plane of the sheet, [100] and [010], and eliminates one of the magnetically poorer crystallographic directions characteristic of oriented silicon-iron materials to date, [111]. The advent of cube-textured silicon iron should liberate the designer of inductive cores from many restrictions imposed by the single-textured product.

Little information on the basic mechanisms involved in the development of cube texture is available. Recent information describes mechanisms of grain-boundary migration and crystal growth, which indicate a dominant role of surface energy (through impurity control) in the development of cube texture.

Cube-textured material has not, as yet, been produced commercially, although considerable test information on laboratory-produced material is available, as Table I illustrates. With the solution of practical production problems, cube-textured silicon-iron strip will fill a very valuable niche in the field of soft magnetic materials. No estimate has been made of the date of commercial availability of this material.

Transformer Hum

During the last decade, a tough problem has faced the power transformer industry. As local power demand expands and power transformers are placed more and more in residential neighborhoods, their humming noise will not be tolerated by near neighbors. While noise of this nature can be controlled by design, a basic cause is magnetostriction of the magnetic core material. This change in length which accompanies the cyclic magnetization of the core amounts, at most, to a few millionths of an inch per inch, but this is enough to generate a steady sonic pulse. Its control has been the subject

of a great deal of research and development.

Dynamic magnetostrictive motion of commercial, grain-oriented silicon-iron strip ranges from small contractive values to moderate expansive values. Modern magnetic domain concepts indicate that these relatively small movements are the result of a predominance of domains preferentially oriented in the rolling direction. This preferred domain orientation occurs as a result of controlled tensile stresses.

Discussion of the theory will show how this works. In crystal-oriented silicon iron, positive magnetostrictive movements are lowered by a tensile stress which generates a strain equivalent to the magnetostrictive elongation. Such a tensile stress causes a spontaneous realignment of domain magnetization into directions parallel to the applied stress.

Conversely, compression applied longitudinally alters the domain pattern to one containing an increasing volume of domains spontaneously magnetized at right angles to the rolling direction. Subsequently, magnetizing such a material in the rolling direction requires 90° domain wall motions which generate a high positive magnetostrictive strain for the domains affected. Figure 1 shows that, for samples having a normal strain concentration, a given compression is much more effective in increasing magnetostrictive movement than a similar tension is in improving it. Since bending involves both tension and compression, the unfavorable effects of the compressive force will predominate. Properties other than magnetostriction are adversely affected by compression stresses.

Practically speaking, every vestige of bending stress cannot be eliminated. To control these unfavorable stresses, it is necessary to develop a way to keep the material under a positive tensile stress at all times. This tensile stress must be sufficient to overcome any conceivable compressive stress encountered during handling or component assembly.

In today's practice, sheets are coated with a composition which, in cooling from some elevated temperature, has a lower coefficient of contraction than the steel, or places the steel in tension by some other mechanism. While the actual tensile stress generated in the steel is small (near 300 psi.), the surface-steel bond must transmit a unit stress of some magnitude without fracture.

It is now common to anneal cold rolled silicon-iron strip in large, tightly wound coils, with the convolutions separated by a magnesia coating. Magnesia not only provides a separation, but, during the high temperatures involved, combines with the natural silica on the strip surfaces to form a glass-like coating. This improves surface insulation and aids in producing tension in the steel. Strip from such an anneal is difficult to use because of its curved

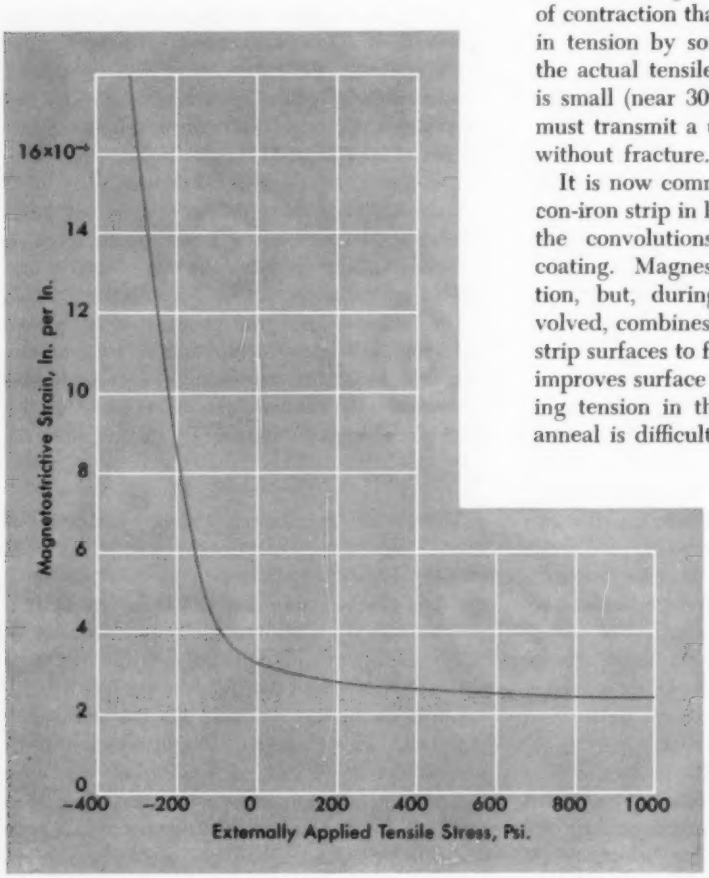


Fig. 1—Graph Showing Magnetostriction Variations Resulting From Applied Stresses on Crystal-Oriented Silicon Iron, Measured Longitudinally. It is apparent that compressive stresses greatly increase magnetostrictive movements. Since this motion causes transformer hum, steel for cores should be under a constant tensile stress.

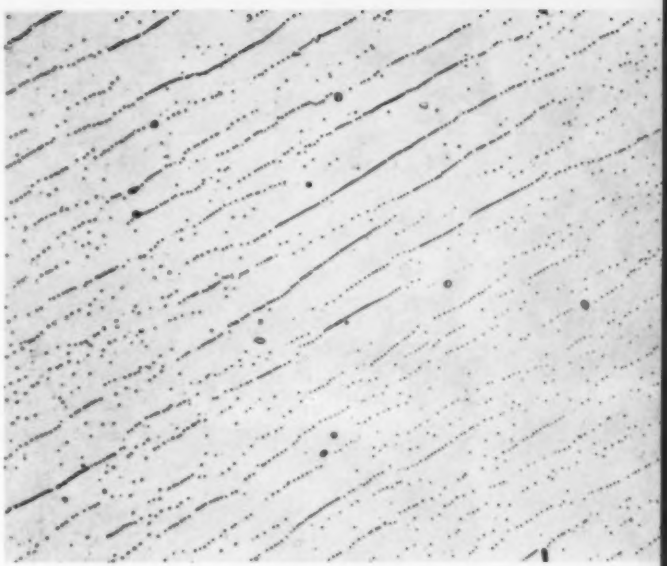


Fig. 2 – Substructure in Fully Processed Silicon Iron After Aging at 100° C. for 15,000 Hr. Note evidence of dislocations and polygonization. Mechanically polished, chrome-acetic acid etch, 750 ×

and eavestrough contour, so must be reflattened. This flattening process creates dislocations within the steel which are difficult to remove by subsequent annealing. If they have no other ill effects, they serve as sinks for interstitial chemical impurities which may alter magnetic characteristics. The accompanying micrograph (Fig. 2) illustrates carbide concentration at dislocation sites in silicon iron.

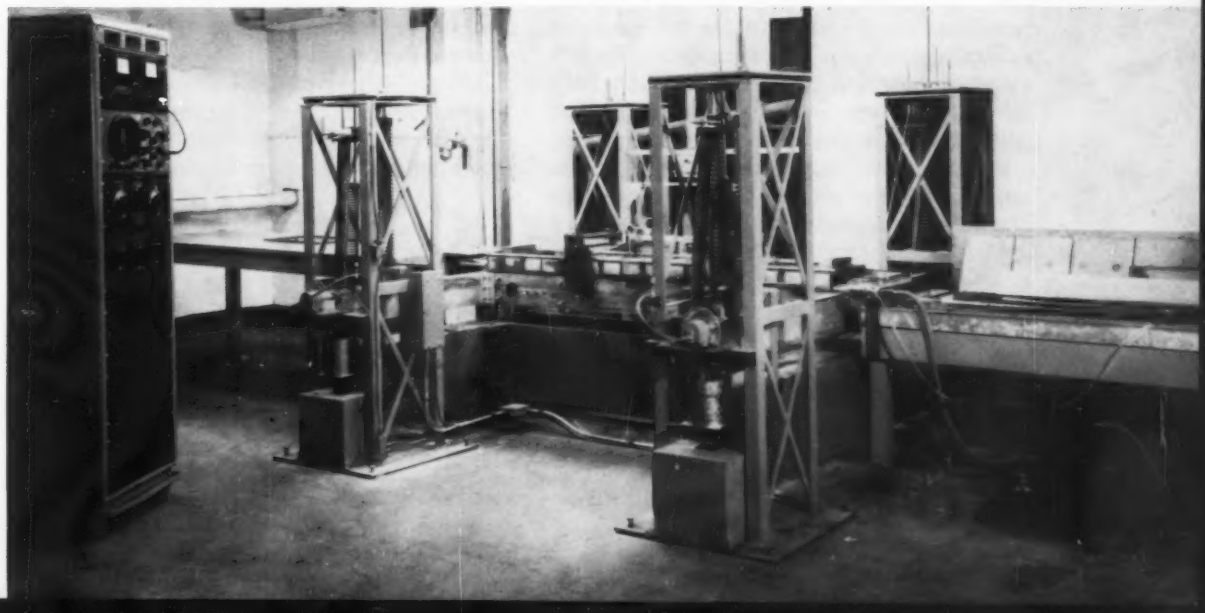
Instrumentation

The advancements made in the past years would have been impossible without improved instrumentation and analytical techniques. Very excellent equipment has been devised for measuring both static and dynamic magnetostriction. The instrument illustrated (Fig. 3) evaluates dynamic magnetostriction on wide and long laminations as they are used in a transformer core. A similar wide-lamination tester for core losses has been of value in more satisfactory use of silicon iron in transformer cores. Various improved hysteresis loop tracers and magnetic comparators have been announced, especially a recording fluxmeter of high sensitivity and an improved magnetizing force measurement system, making it suitable for evaluating very small samples.

In the field of analytical techniques, rapid determination of traces of carbon is now possible with commercial equipment equivalent in precision to the low-pressure combustion method. Modifications for minimizing errors in the combustion method for determination of traces of sulphur in ferrous alloys have also been described. The damaging effect on magnetic properties of both of these elements was mentioned before. Techniques for the identification of microconstituents of steel have been described; also, a number of studies of the behavior of silicon nitride in silicon irons have been published.

This brief survey indicates that technical progress with silicon irons for magnetic purposes is accelerating. Twelve years will be too long to wait for the next review.

Fig. 3 – This Equipment Measures Dynamic Magnetostriction on 6-Ft. Power Transformer Core Laminations



Space-Age Beryllium . . . Its Technology

*Reported by ROBERT H. GASSNER**

Learning how to deal with beryllium has proved to be a tough problem. But the efforts are well worth-while because the metal has those properties such as low density, good heat conductivity and high modulus of elasticity which designers need in meeting the challenge of space travel. (A-general, T24, 17-57; Be)

"THE NEED IS THERE; economics is not the question – not when each additional pound of satellite costs about 10,000 lb. at launching." Thus spoke C. J. Giemza of the Martin Co., at the recent A.I.M.E. Southwest Metals and Minerals Conference. In stating the case for continued development and use of beryllium for structural purposes, he also pointed out how the metal's properties, in addition to low density (it is only 0.08 g. per cc. heavier than magnesium), make it uniquely qualified as a structural metal for space vehicles.

To the designer of terrestrial vehicles, the most attractive properties are, of course, the moduli of elasticity – 42,000,000 psi. in tension and 49,000,000 in compression, according to Martin. (There is some departure from proportionality in stress-strain curves at about one third the yield strength, but small enough to be neglected in structural applications.) However, beryllium's attractive stiffness-to-density ratio accounts only in part for the designer's enthusiasm. He also sees the metal's inflexibility as allowing him to use a more efficient but less ductile ceramic coating – one which would crack if applied on a more elastic base metal.

Strangely enough, it appears that fatigue failures, one of the problems which continually plague the mundane designer, will be nonexistent in beryllium structures. C. O. Mathews, Lockheed Missile Systems Div., cited tests on sheet specimens which indicate that the endurance limit of beryllium is about equal to the ultimate tensile strength!

When the spacecraft designer examines his challenging temperature control problems, he finds the thermal characteristics of beryllium exceptionally well suited to his needs. First, the high moduli of elasticity are maintained over a greater temperature range than by any other metal. Second, its specific heat (0.52 cal. per g. per °C. at 20° C.) makes it an ideal "heat sink" (Fig. 1). It can soak up frictional heat during re-entry into the atmosphere and solar heat almost 2½ times as efficiently as aluminum. In other words, an aluminum sink designed to experience the same temperature rise would weigh nearly 2½ times as much. Third, the high thermal conductivity of beryllium (0.38 cal. per sq.cm. per cm. per °C. per sec.) minimizes stresses resulting from the differential expansion of hot (sunlit) and cold (shaded) surfaces.

What are the problems in using beryllium?

Intensive work is needed in the field of joining. Commercial production of sheet in reasonably large sizes is also needed. Mr. Giemza dismissed the ductility problem as "not important", saying, "Will it withstand the stress? should be the only criterion". He foresees future use of beryllium for meteorite protection, heat sinks, and proton shields in multi-ton space vehicles.

Improvement in Primary Production

Producers of beryllium have been striving to make the metal more attractive to designers. Some of the progress toward reducing the cost of the metal, making more forms available, and

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Fig. 1 – Beryllium Billet for N.A.S.A.'s Project Mercury. Billets such as this, each 62 in. in diameter and 5 in. thick, are made by powder metallurgy techniques. They will be used after forging as heat sinks on our first manned space capsules. (Photos courtesy Brush Beryllium Co., except where noted)

increasing its reliability were described by J. P. Denny of the Beryllium Corp.

The first product of ore separation processes, known as "impure bead", is cleaned and remelted in vacuum to produce beryllium ingots of 99% purity. Unfortunately, the ingots are large-grained, have no ductility and thus are unworkable. Inoculation and vibration designed to correct this situation have not yet been successful. Study of ingots made by electron beam melting (then worked by conventional techniques) is just getting under way. In the absence of less costly methods, production is now based on hot pressing (250 to 1000 psi.) of −200-mesh powder produced by grinding the ingots in a protective atmosphere. Pressing is at 1900 to 2000° F. in a vacuum of less than 100 microns. The billets are close to theoretical density, essentially isotropic in mechanical properties, and ready for machining. Precautions must be taken during machining because of the toxicity of finely divided beryllium.

Reduction of billets by extrusion, rolling, and forging is of major economic importance because it reduces machining and the amount of metal wasted in the form of chips. Beryllium is extruded in steel jackets (Fig. 2) at 1650 to 2000° F. at pressures up to 200,000 psi. Sheet is rolled in steel jackets at about 1500° F. Press forging is being done on a limited basis. A recent development of economic importance consists of encapsulating −200-mesh powder in a steel container, press forging the assembly and removing the steel jacket by pickling. Cost is reduced by eliminating hot pressing.

During hot working, excessive grain growth can occur above 2000° F. However, manufacturers are generally able to restrict grain size to 0.035 mm. or less. Also, ductility increases parallel to the direction of working, but decreases concurrently in the transverse direction.

Fabrication Experience Increases

Progress is being made in wrought beryllium products. According to W. W. Beaver of Brush Beryllium Co., corrugated foil 0.005 to 0.010 in. thick can be made in lengths up to 10 ft. Width, however, is limited to a few inches. Structural sandwich panels have been produced by spot welding corrugated strips together to from a honeycomb core (Fig. 3) and attaching 0.020-in. face plates by brazing. Oddly enough, the most difficult problem encountered during fabrication of the latter was machining the core to size by standard impregnation techniques. In this practice the pockets of the honeycomb core are filled with water or similar material and frozen. The ice supports the thin, vertical foil during machining. It is removed when the desired contour has been obtained

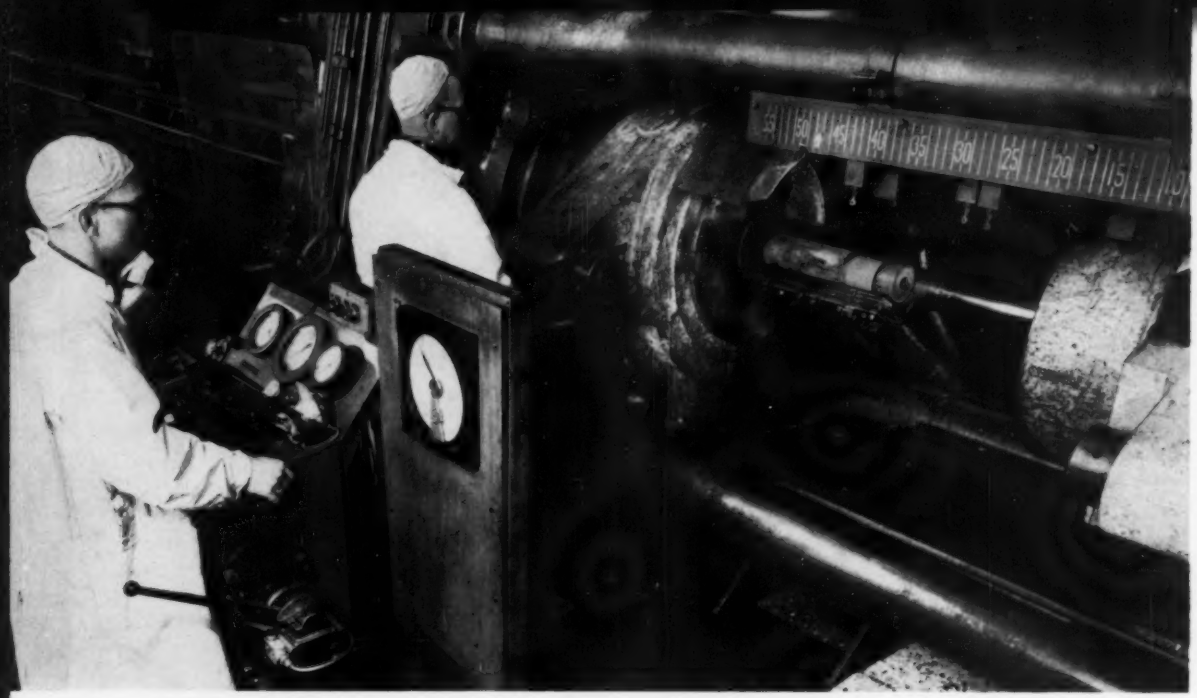


Fig. 2 – Steel-Jacketed Beryllium Billet and Graphite Follower Block in Position for Hot Extrusion on 1750-Ton Press. Extrusion is performed at 1650 to 2000° F. using pressures up to 200,000 psi. Operators are issued respirators for emergency use should steel jacket rupture during extrusion. (Courtesy Beryllium Corp.)

so that the 0.020-in. face plates can be brazed to the core.

Weldability of beryllium is also being studied. Welded tubing has been made from thin sheet (0.020 in. thick) by the argon-shielded tungsten-arc process while working in a chamber filled with argon. Multipass weldments up to 1 in. thick are being attempted. At room temperature, the mechanical properties of weld metal are somewhat lower than those of base metal. Above 600° F. for hot pressed products and 1000° F. for extruded products, however, the strength of the bead exceeds that of the finer-grained base metal.

A great deal of interest has arisen in possible hydraulic and structural applications of extruded beryllium (Fig. 4). Tubing in 2 to 3-ft. lengths with ⅜-in. I.D. and 0.050-in. walls can be made by warm extrusion at temperatures down to 800° F. Difficulty in maintaining lubrication is chiefly responsible for the current limitations on length. Thin-webbed channel and H-shapes, 10 to 15 ft. long, have been successfully extruded inside a mild steel jacket.

Progress is being made toward a goal of producing long lengths of 0.005-in. diameter wire. Short lengths of 0.015-in. and long lengths of 0.025-in. wire are now available. By using the proper combination of warm drawing and annealing, most of the original isotropy has been retained.

Pyrolytic refining processes have been improved to the point where the product now contains less impurities than usually specified as maximum for metal refined electrolytically. Availability of finer powder for hot pressing in the near future (finer than the −200 mesh currently used) holds the promise of 25 to 30% higher properties at room temperature. A general increase in mechanical properties may also come from adding 2.5 to 3.0% beryllium oxide to the powder.

Some beryllium compounds have attractive properties, but the high temperatures necessary for mill fabrication (2600 to 2900° F.) have hampered progress. The modulus of elasticity of zirconium beryllide ($ZrBe_{13}$), for example, is 25,000,000 psi. at 2300° F., 20,000,000 psi. at 2500° F. and 10,000,000 psi. at 2700° F.; its fabrication characteristics are very similar to those of beryllium, but at about 1500° F. higher.

Basic Studies Yield New Knowledge

High-temperature X-ray diffraction has revealed that a phase change occurs at 2280° F. (1250° C.), some 86° F. (30° C.) below the melting point. The high-temperature phase has a body-centered cubic structure (lattice parameter, 2.55 Å) and is probably more ductile at room temperature than the low-temperature phase which is close-packed hexagonal. Work

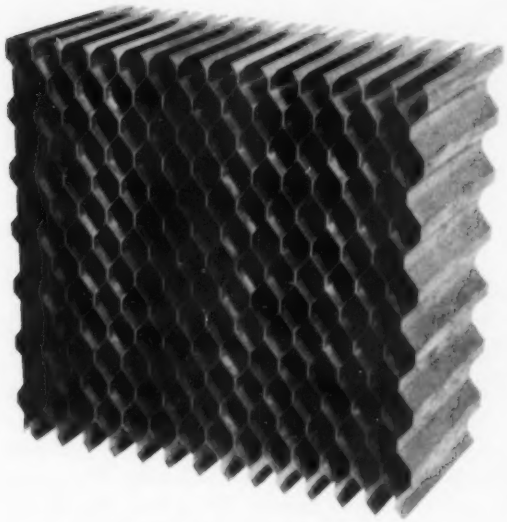


Fig. 3 – Beryllium Honeycomb Was Fabricated by Spot Welding Corrugated Foil

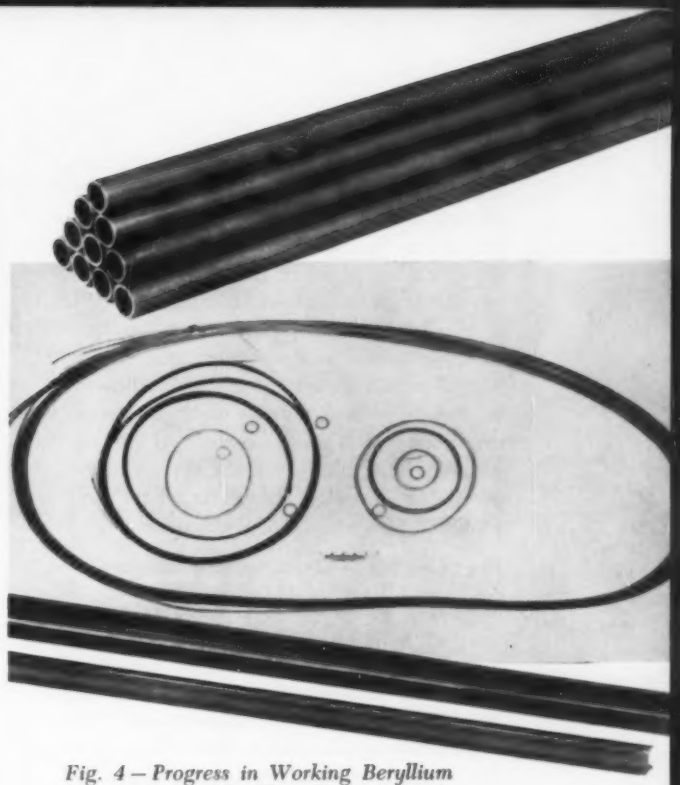


Fig. 4 – Progress in Working Beryllium Is Demonstrated by These Wrought Products. Top: warm extruded tubing; center: warm drawn wire (0.031 to 0.092 in. in diameter); bottom: structural extrusions

financed by the Air Force is now exploring the possibility that this ductile phase can be retained down to room temperature.

Thus far, many binary and some ternary alloys have been studied without success. One of the chief obstacles has been the weight of the added elements. Addition of just a few atomic per cent of a heavier element such as nickel is equivalent to adding about six times as much in weight per cent; this nullifies beryllium's density advantage.

Work sponsored by the Atomic Energy Commission and reported by S. H. Gelles of Nuclear Metals, Inc., has shown that impurities play an important role in determining mechanical properties. Elongation distinctly depends on temperature; it increases normally until about 750° F. (400° C.) is reached, decreases to a minimum at about 1110° F. (600° C.) then resumes its normal rise. This phenomenon is ascribed to the precipitation of compounds which contain impurities. The effects of impurities have been confirmed by work with single crystals and also by aging and strain-aging reactions.

Aging characteristics of material quenched from 2010° F. (1100° C.) were studied by measuring electrical resistivity after exposure to temperatures in the range of 390 to 1830° F. (200 to 1000° C.) for periods up to a month. At 1110° F. (600° C.), the resistivity decreased steadily with increased aging time to about two-thirds of the as-quenched value; at 1470° F. (800° C.), the resistivity decreased quite rapidly, but leveled out at about 85% of the unaged value. Aging 24 hr. at 1110° F. (600° C.) also increased the ultimate tensile strength from 60,000 psi. to 80,000 psi., and the elongation from 2.5 to 12%. Another interesting characteristic revealed by these experiments was the development of distinct yield points in stress-strain curves of specimens aged about 2 hr. at 750° F. (400° C.) and from 2 to 24 hr. at 1110° F. (600° C.).

Qualitative analysis of inclusions in relatively impure single crystals has shown them to be rich in iron, chromium, and manganese with a generalized formula of MBe_{12}. However, extra lines found in X-ray diffraction photographs indicate that other elements are present to a lesser degree.

Several approaches such as alloying and deoxidation are being followed to solve the problem of brittleness of beryllium. An unusual alternative, described by S. R. Maloof of Avco Corp., is to form a two-phase material consisting of beryllium grains surrounded by a ductile matrix. For example, by sintering a beryllium powder compact at 1920° F. (1050° C.) in the presence of a silver-lithium

alloy containing 0.2 wt.% lithium, the result is a composite of beryllium globules in a matrix containing 16.9% silver. Although this composite can be reduced 50% by cold rolling, its density is 4.5 g. per cc., about 2½ times that of beryllium and equivalent to titanium. With 10 at.% silver the composite has no ductility because the matrix is discontinuous. By switching to mixed powder techniques, however, a composite with a density of 2 g. per cc. was produced which could be reduced 30% by cold rolling. The microstructure of this alloy consisted of rounded beryllium particles surrounded by a very thin layer of silver.

Heat Control Is Major Space Challenge

Most of the problems of temperature control in space vehicles arise from the relatively narrow temperature range within which equipment and personnel can function effectively. Absorbed and emitted radiant energy, internal power dissipation, and the thermal paths within the structure must therefore be controlled.

Obviously, correct absorptivity and emissivity of radiant energy are necessary properties for external coatings. Reduction of thermal paths requires use of materials with a high conductivity-to-density ratio for structural parts and outer shells. Lithium, beryllium and aluminum are most suitable, but alloying for strength or workability results in heavy penalties in conductivity.

Interfaces between joined parts also interfere with heat flow, especially in vacuum. Machining of faying surfaces plus insertion of conformable metal sheets or thin entrapped grease layers between them can improve heat transfer. Designing for welded construction, however, is the best solution.

Materials in Space

It must be pointed out that simulating a space environment in a laboratory is extremely difficult, if not impossible. Thus many inferences on the effects of space conditions on materials must be based on insufficient knowledge.

E. C. Burke, Lockheed Missile Systems Div., and L. D. Jaffe, Jet Propulsion Laboratory, California Institute of Technology, pointed out that the major factors in space which affect materials are radiation, meteoritic matter, temperature variations, and vacuum. Detrimental results such as embrittlement of metals caused by known varieties of radiation are fairly well understood. Radiation in solar winds and in the low-energy spectrum of Van Allen belts could be significantly more damaging. Current estimates of surface erosion resulting from collision with meteoric dust at 179,000 miles per hr. vary considerably because estimates of frequency of such collisions range from 30 to 3000 per sq.cm. per yr. Collisions with larger particles will pit external surfaces, spall the back of thin materials (if the shock wave intensity exceeds the ultimate tensile strength), and penetrate occasionally.

To the metallurgist, high vacuum is probably the most important factor influencing the behavior of materials in space. Evaporation of magnesium at 200° F. is somewhat less than 1×10^{-6} in. per yr., but at 500° F. it amounts to 0.4 in. per yr., and zinc and cadmium evaporates at approximately 100 times and 10,000 times that rate, respectively. Furthermore, it is quite possible that evaporation is increased by radiation.

Lubrication problems created by the high vacuum in outer space will probably be the most challenging of all. Oils and oil components of greases will evaporate; solid lubricants will often fail to lubricate. Simultaneously, evaporation and sputtering will eliminate absorbed and adsorbed layers and produce fantastically clean surfaces — so nearly absolute that they will often catalyze the polymerization of greases and weld together by atomic diffusion if unlubricated.

Various approaches to these problems are being considered, but laboratory investigations are limited because a vacuum of at least 1×10^{-9} mm. of mercury, considered necessary to maintain sufficient surface cleanliness for valid test results, cannot be obtained. Where practicable, joints sealed hermetically are the most obvious answer but even partial enclosure will greatly increase life of organic lubricants. Lubricants of low vapor pressure have useful lives, but are only partially effective in reducing friction; they also tend to creep on ultra-clean surfaces.

Solid film lubricants have sometimes been successful, but procedures must be rigorously controlled. Vacuum deposited films of silver and molybdenum disulphide appear promising. Contacting surfaces of widely dissimilar materials, such as carbide, sapphire, or glass-reinforced teflon with steel, is another way to reduce friction. In most instances, evaluations must await actual tests in space, and vehicles have already been allotted for this purpose.

Heat Treating Large Steel Castings

By THOMAS DITCHFIELD
*and ROBERT G. WAITE**

Direct-fired, radiant gas burners maintain a uniform temperature in the furnace which gives closer control of the operation. This is important for large, irregularly shaped castings which are difficult to heat treat. (J-general, W27g; ST, 5)

IN RECENT YEARS, MAKERS of steam turbines have been required to design and build larger units for operation at higher temperatures and pressures. General Steel Castings Corp. has been supplying turbine shells made of special alloy steels. In the as-cast condition, such steel castings are relatively brittle, with poor mechanical properties, and must be heat treated to make them serviceable.

Specifically, the heat treatment must refine the grains, break up the as-cast structure, relieve stresses, and improve mechanical properties. The heating and cooling cycle selected will depend upon the chemical composition, section size and design, and final mechanical properties desired. To accomplish these objectives, castings may be (*a*) annealed, (*b*) normalized (with or without subsequent tempering), or (*c*) quenched and tempered.

An annealing cycle involves heating slowly to a temperature slightly above the upper critical point, holding at this temperature for a suitable period and then cooling slowly in the furnace.

A normalizing treatment consists of heating to a temperature at least 100° F. above the upper critical point, soaking for the required period and cooling in still air. A higher normalizing temperature, compared with an annealing treatment, produces a larger grain size. This improves creep strength, according to the turbine builders.

Shell castings are usually quenched in air by spacing four to six 3-hp. fans at the proper points around the load after its removal from the furnace. Inner surfaces such as holes may be cooled with jets of compressed air.

Air cooling from the normalizing temperature results in higher hardness and strength than is achieved by annealing but may result in some residual stress due to variable cooling rates in sections of different thickness. These stresses are removed and the hardness reduced by a tempering treatment, which consists of heating the casting to a subcritical temperature, soaking, and then furnace or air cooling.

Turbine Shell Castings

A typical casting produced at the Eddystone Works is shown in Fig. 1. Weighing about 70,500 lb., this shell is 17 ft., 5 in. long, 4 ft., 4 in. high, and 10 ft. wide, with metal sections from 2 to 16 in. thick. Such castings, because of their size, irregular shape and difficult heat treating characteristics, require special care in heat treating.

After solidifying, the turbine shells are moved to the cleaning room, where they are visually and magnetically inspected. Defects are removed and cavities are welded. The castings, now ready for heat treatment, are loaded onto a furnace car.

Radiant-Fired Furnace

The two car-bottom furnaces at the Eddystone Works demonstrate the speed and control possible in heat treating large castings by direct firing with radiant gas burners. Each of the furnaces, designed for normalizing and temper-

*Mr. Ditchfield is mechanical superintendent and Mr. Waite is plant metallurgist, General Steel Castings Corp., Eddystone, Pa.

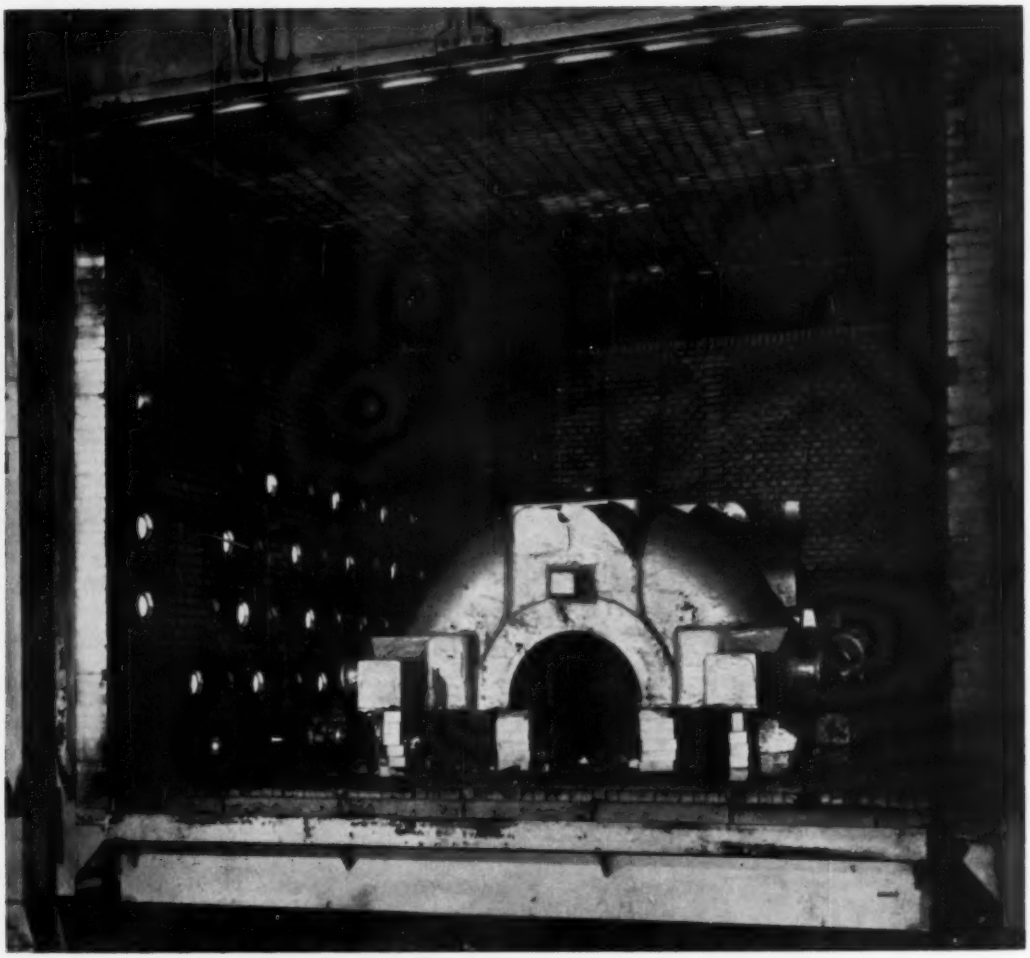


Fig. 1 – Alloy Steel Casting (Weight 35 Tons) After Normalizing Cycle. Note pattern of radiant burners in furnace sidewall. During a tempering cycle, one half of the burners are shut off by closing a valve

ing large castings, has a firing arrangement which not only provides fast, uniform heating to 1700° F., but can also provide uniform soaking heat at any tempering temperature.

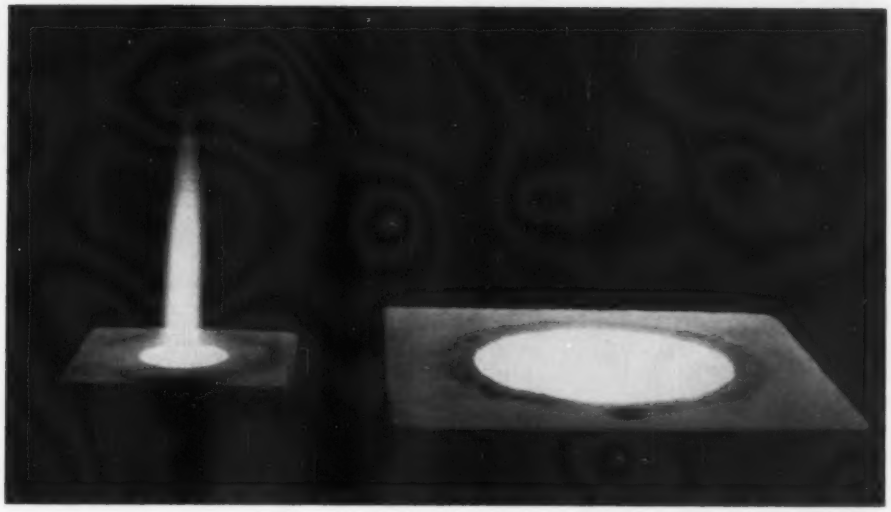
Heat is supplied by 36 "Duradiant" burners set in the sidewalls in the pattern shown in Fig. 1. Three additional burners in the sidewalls just inside the door counteract heat losses. Hearth effects are overcome by a row of flame-type "Refrak" screen burners, firing into the space between car top and casting bottom.

Burner Design – Each radiant burner consists of a kiln-fired, ceramic-lined cup (Fig. 2). Burning of a gas-air mixture against this cup-shaped refractory surface makes the surface incandescent, and radiant heat is beamed directly on the casting. Combustion is confined to the cup, so there is no flame impingement on the work. Very wide loads have been heat treated with no evidence of hot spots or nonuniform heating, even though the clearance between burner and charge was only 1 ft. Experience has shown that a furnace of this type can reduce heat treat cycle time 20% – compared to that required with furnaces equipped with less efficient, long-flame burners.

Use of radiation burners in the wall permits a saving in floor space, since each 200-ton capacity furnace occupies an area only 25 ft. long by 18½ ft. wide*.

A completely combustible mixture of gas and

*Effective load chamber: 20 ft. long by 13½ ft. wide (door is 12 ft. wide) by 10½ ft. high at crown of the arch.



air is supplied to the burners through inspirator-type mixers. No secondary air is required. Heat input is regulated by motorized valves in the air supply line. For low-temperature treatments, half the burners in both zones can be turned off by closing a single slide valve.

The flame-type Refrak burners are used with a fired refractory flame-screen, resulting in a larger total heat output and a high turndown ratio. The difference in firing characteristics between the radiant and the flame-type burner is illustrated in Fig. 2.

The combustion air and gas are piped to the burners in two zones controlled by separate thermocouples attached to indicating controllers. Temperatures at two points on the surface of the casting are recorded on a four-point strip chart recorder.

Furnace Operation

The furnace operator starts the heat treat cycle by setting the rate-of-rise control in each furnace zone at 100° F. per hr. Next he adjusts the holding temperature set point at the desired temperature, and the holding timer at the desired soak time. These settings will vary for different heat treat loads. The heating rate may be stepped up or slowed down depending on the composition of the steel. Holding time is generally 1 hr. per in. of casting thickness, but never less than 4 hr. total.

The burners are lighted and the car is pulled into the furnace. The normalizing phase of the cycle proceeds under automatic control. When the normalizing soak is complete the casting

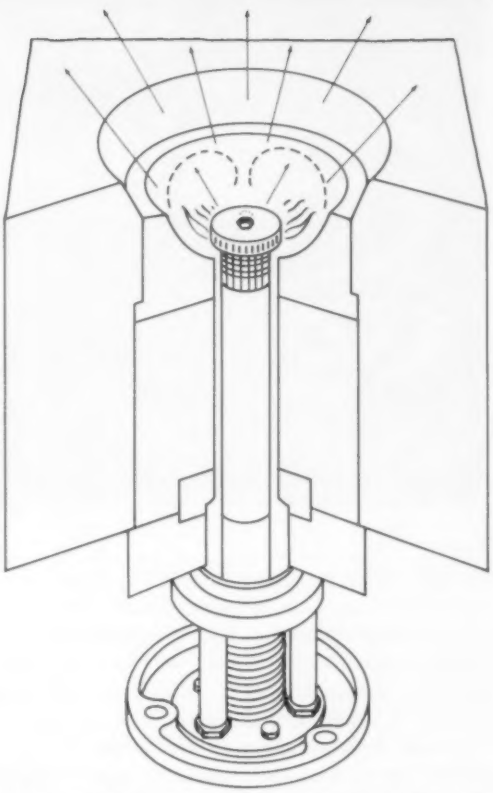


Fig. 2 – Burners Used in Radiant-Fired Furnaces. "Refrak" screen burner (top, left) and "Duradiant" burner (top, right) are shown releasing heat at same rate. Note lack of "stingout" from radiant burner. Drawing illustrates operating principle of radiant burner. Gas-air mixture is introduced through pipe at center. The cup-shaped refractory surface becomes incandescent and radiates heat directly on the work

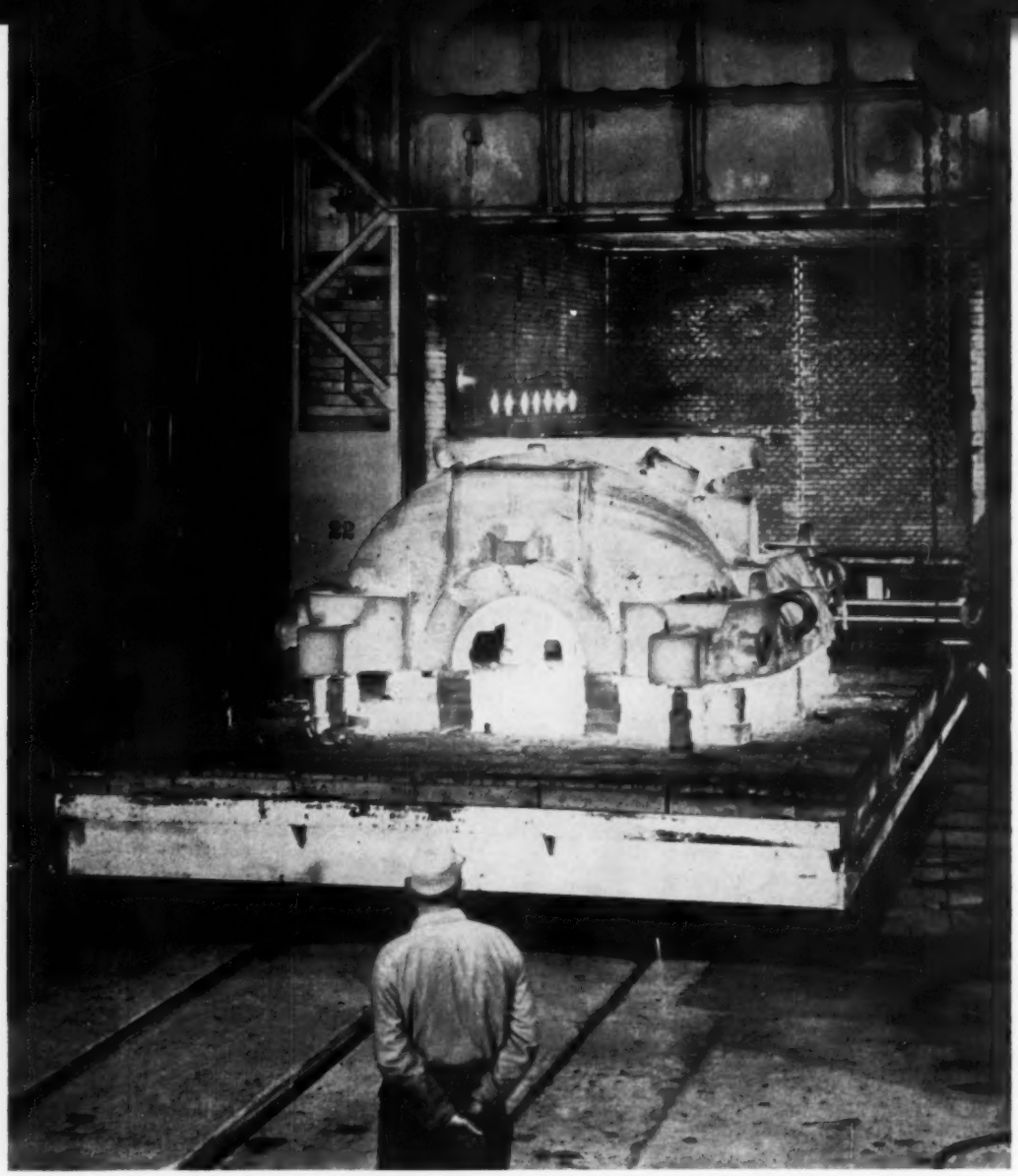


Fig. 3 – Upon Completion of Normalizing Cycle, Turbine Shell Casting Is Removed From Furnace and Air Cooled

is withdrawn, as shown in Fig. 3, and allowed to air cool to 400° F. minimum.

Now the operator sets the furnace for the tempering cycle. The slide valve in the main air line is closed, shutting off about half the radiant burners in each wall. He sets a new cycle on the control panel, which involves uniform reheating at 400 to 1200° F. and holding for 1 hr. per in. of maximum thickness. The castings are returned to the furnace and the tempering cycle proceeds automatically. Upon completion of the heating and holding portions of the tempering cycle, the castings are cooled slowly at a rate less than 125° F. per hr. This is usually done by turning the burners off and allowing the casting to remain in the closed furnace until the temperature drops below 525° F. The castings are then ready for re-inspection, followed by finishing.

Permissible heating rates in these large, radiant-fired furnaces are considerably higher than those used with conventional car-bottom furnaces. This is due to the uniformity of heating resulting from a balanced pattern of radiant heat sources, together with high heat transfer efficiency. Some additional efficiency is achieved because these furnaces require no warmup; both the normalizing and tempering cycles can be started from a cold furnace.

Degassing and Cleaning Aluminum With Nitrogen and Nitrogen-Chlorine Mixtures

*By ROY F. GOTTSCHALK**

Removal of hydrogen and entrapped oxides from molten aluminum is more consistent from heat to heat if a special degassing cup is added near the top of the nitrogen lance or mixtures of chlorine and nitrogen are used. (E25s; Al)

THE PROBLEM OF OXIDE INCLUSIONS and dissolved hydrogen is familiar to all concerned with melting and casting of aluminum. Hydrogen in aluminum can be either beneficial or detrimental depending on the application of the casting. Since it is rejected from the metal during solidification, hydrogen may prevent localized shrinkage or dimensional change in cast structures. On the other hand, hydrogen present in primary and secondary ingot is undesirable because of its detrimental effect on the quality of the rolled product. In essence, then, the problem of controlling hydrogen in aluminum is a direct function of the properties that are required in the casting.

Unlike hydrogen, oxides in aluminum products are always objectionable. Oxides affect physical properties, surface finish, machining quality, and drawing characteristics. As a result, aluminum melting and pouring operations are designed to minimize their formation and entrapment.

The use of chlorine gas to remove dissolved hydrogen and included oxides in aluminum melts is well known, but the mechanism by which they are removed is not thoroughly understood. Nevertheless, very satisfactory

*Metallurgist, Research and Development Dept., National Cylinder Gas Div. of Chemetron Corp., Chicago.

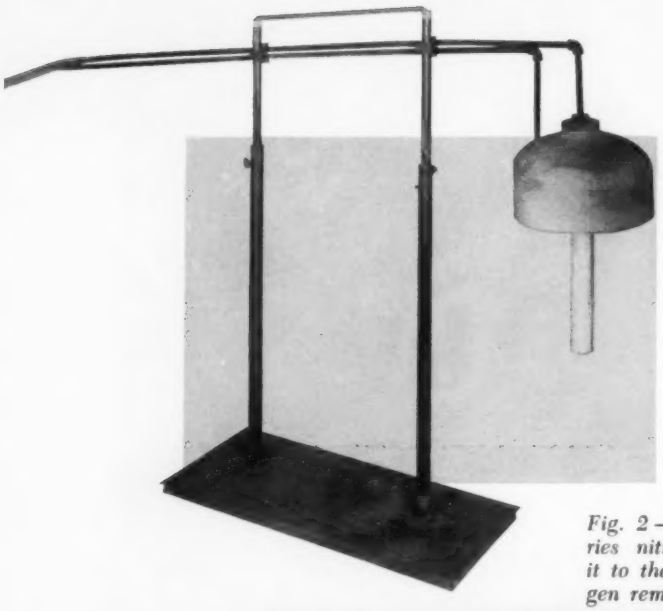


Fig. 1 – Equipment Used for Flushing Molten Aluminum With Nitrogen. Lance projects beneath surface and flushing cap is partially immersed to give positive seal. Atmosphere under cap is kept free of air by continuous flushing with nitrogen during degassing operation

Fig. 2 – Flushing Cap in Operation. One gas line carries nitrogen to submerged lance; other line directs it to the flushing cap. Combined effect is better hydrogen removal especially during periods of high humidity.

results are obtained consistently with chlorine gas but not without obnoxious fumes and equipment corrosion.

Degassing With Nitrogen

Flushing aluminum melts with nitrogen and other inert gasses removes dissolved hydrogen by a combination of agitation, cooling, and gas diffusion. Agitation created by the flushing technique provides a large gas-metal interface between a scavenging gas essentially free of hydrogen and the molten metal which contains a relatively large amount of hydrogen.

Removal of the hydrogen and other dissolved gases occurs by diffusion into the inert gas bubble. As long as the hydrogen diffuses freely from the metal, continued flushing will lower the concentration of this gas in the molten aluminum. There has been a problem, however, in providing continuous diffusion. Tests show that the surrounding atmosphere influences the rate of hydrogen removal from the bath. Hydrogen can be re-absorbed, for example, because of reactions between the molten aluminum and moisture in the air. Thus, the results obtained when nitrogen is injected through the conventional open-end lance vary from day to day. In fact, it is sometimes impossible to degas aluminum completely in spite of prolonged flushing with nitrogen.

One way to combat the problem is to use the special flushing cap shown in Fig. 1. In this technique, which is best suited to small operations, nitrogen that is injected below the surface of the molten bath produces rapid agitation within the flushing cap. The gas is also introduced directly into the flushing cap to maintain an oxygen-free atmosphere. Because the flushing cap is partially immersed in the molten metal, it seals the surface from the surrounding air. Scavenging gas is injected continuously during the degassing cycle and exhausted through the orifice at the top of the flushing cap. No special grade of gas is required. Nitrogen containing 30 grains of water per 1000 cu.ft. (−45° F. dew point) is satisfactory and readily available.

more in depth and the gas flow is not great enough to cause splashing of the molten metal.

Chlorine contents above 10% do not significantly increase the rate of hydrogen removal, but do produce objectionable odors. With chlorine below 10%, dross skimmings become "wet" with aluminum and dragout increases. Good results with the 90% nitrogen, 10% chlorine, demonstrated in Fig. 3, have been confirmed by experience in degassing 20,000 to 65,000-lb. heats in reverberatory furnaces. Also, this mixture does not appear to cause corrosion of equipment.

The degree of hydrogen removal varies from one furnace to another. Complete degassing is not possible in a furnace if the burners are ignited. Subsequent treatment of the metal in

Fig. 3 — Test Samples of 6063 Aluminum Alloy Flushed With a Mixture of 90% Nitrogen and 10% Chlorine and Solidified Under Reduced Pressure. Reduction of voids indicates progressively better degassing with longer flushing time

The flushing cap offers two distinct advantages. First, only that metal under the cap (where it is protected by an atmosphere of nitrogen) is agitated. Because the surface of the metal outside the cap is not disturbed so as to break its oxide layer, it does not pick up a significant amount of hydrogen. Another advantage is that agitation cools the metal contained under the cap. This aids in degassing because hydrogen becomes less soluble in aluminum as the temperature drops.

Nitrogen-Chlorine Mixtures

Consistent results can also be obtained with mixtures of nitrogen and chlorine. Available equipment provides a gas flow of desired composition at 10 to 90 cu.ft. per hr. to one or two lances. In this method, the gases are mixed by a simple proportioning system before being injected into the aluminum.

Tests indicate that no objectionable odors are experienced with a 90% nitrogen, 10% chlorine mixture as long as the bath is 1 ft. or

an outside charging well or in a ladle, however, has been found to reduce the gas content to an acceptable level.

Flux and Dross Removed

Although hydrogen is not completely removed in the presence of a combustion atmosphere, considerable amounts of flux and dross particles are flushed from the bath. When the lance is moved along the hearth, large flux and dross particles are loosened and brought to the surface by the flushing action of the gas. No excessive metal carry-out is experienced.

Over-all evaluation of treatment with the 90% nitrogen, 10% chlorine mixture reveals that the consumption of gas will vary from 0.5 to 2.0 cu.ft. per 100 lb. of aluminum. In general, satisfactory degassing is achieved if the surrounding atmosphere does not contain combustion products and if excessive agitation is not used. Delivery of the flushing gas must be regulated to provide a "rolling" rather than a "breaking" bubble.

A Homologous Temperature Scale for Metals

*By J. H. WESTBROOK**

Based on the principle that metallic elements behave similarly in accordance with their absolute melting points, the Data Sheet on p. 100-B can be used in the design of experiments on creep, recrystallization, sintering of powders and other properties which are temperature dependent. (P12)

THE USE OF A TEMPERATURE SCALE based on the absolute melting point of metals is a concept dating back over 40 years. The basic idea is that two different materials, A and B, should behave similarly at temperatures T_A and T_B (° Kelvin) where: $\frac{T_A}{Tmp_A} = \frac{T_B}{Tmp_B}$.

This concept can be applied to such properties as elastic modulus, thermal expansion coefficient, recrystallization temperature, and creep†. Similar correlations have also been found for sintering of powders, onset of plastic flow in oxides, and hardness data.

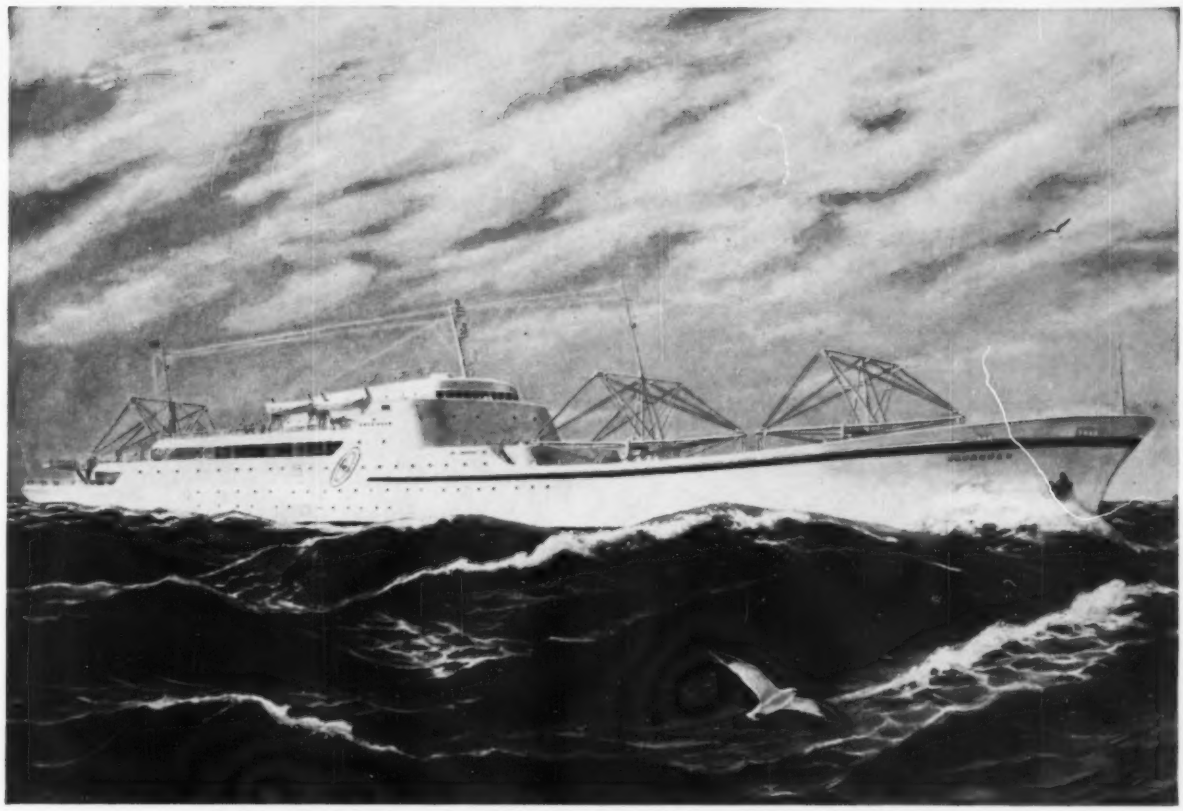
We have found that this relationship is much easier to apply when the graphical plot illustrated in the Data Sheet (p. 100-B) is used. In particular, the need for an intermediate conversion of the temperature of interest to and from absolute temperature and the Celsius or Fahrenheit scales is eliminated. There are thus provided scales for melting point, test temperature and homologous temperature. While homologous temperatures for materials of any melting point may be read from the chart, horizontal rulings for many of the common metals have been provided for convenience. While the chart is virtually self-explanatory, a couple of examples may be helpful.

For instance, note from the chart that lead is being hot worked at room temperature since 20° C. is at a homologous temperature of 50 while copper at the same actual temperature can be cold worked since it is then at a homologous temperature of 22. This comparison is made by interpolating between the 0 and 50° C. curves, and following the interpolated curve from the horizontal line marked "lead" up to that marked "copper". The homologous temperatures are read off the bottom scale at points corresponding to the intersections of the horizontal lines and the room-temperature curve.

Furthermore, if one wishes to estimate at what temperature a number of different metals —say mercury, aluminum, nickel, columbium and tungsten, for example – might be expected to behave similarly to copper at 100° C., one first determines that 100° C. for copper is about 27 on the homologous scale. Then, by following up and down a vertical line through this point, corresponding temperatures of −210° C. for mercury, −15° C. for aluminum, 200° C. for nickel, 470° C. for columbium and 740° C. for tungsten are read by interpolation between the curves at the intersection of this vertical line and the horizontal line representing the melting temperature of each metal.

*Metallurgy and Ceramics Research Dept., General Electric Research Laboratory, Schenectady, N.Y. The author wishes to thank J. D. Nisbet, who first encouraged him to reduce this idea to practice, and E. F. Paquette, who helped make the graph.

†"Corresponding or Homologous Temperatures", by A. M. Portevin, *Metal Progress*, October 1951, p. 109.



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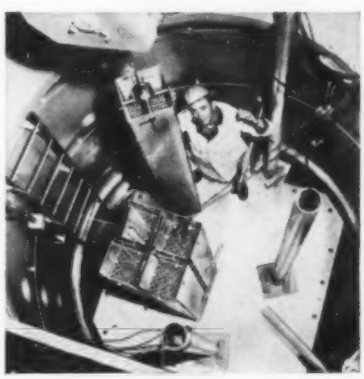

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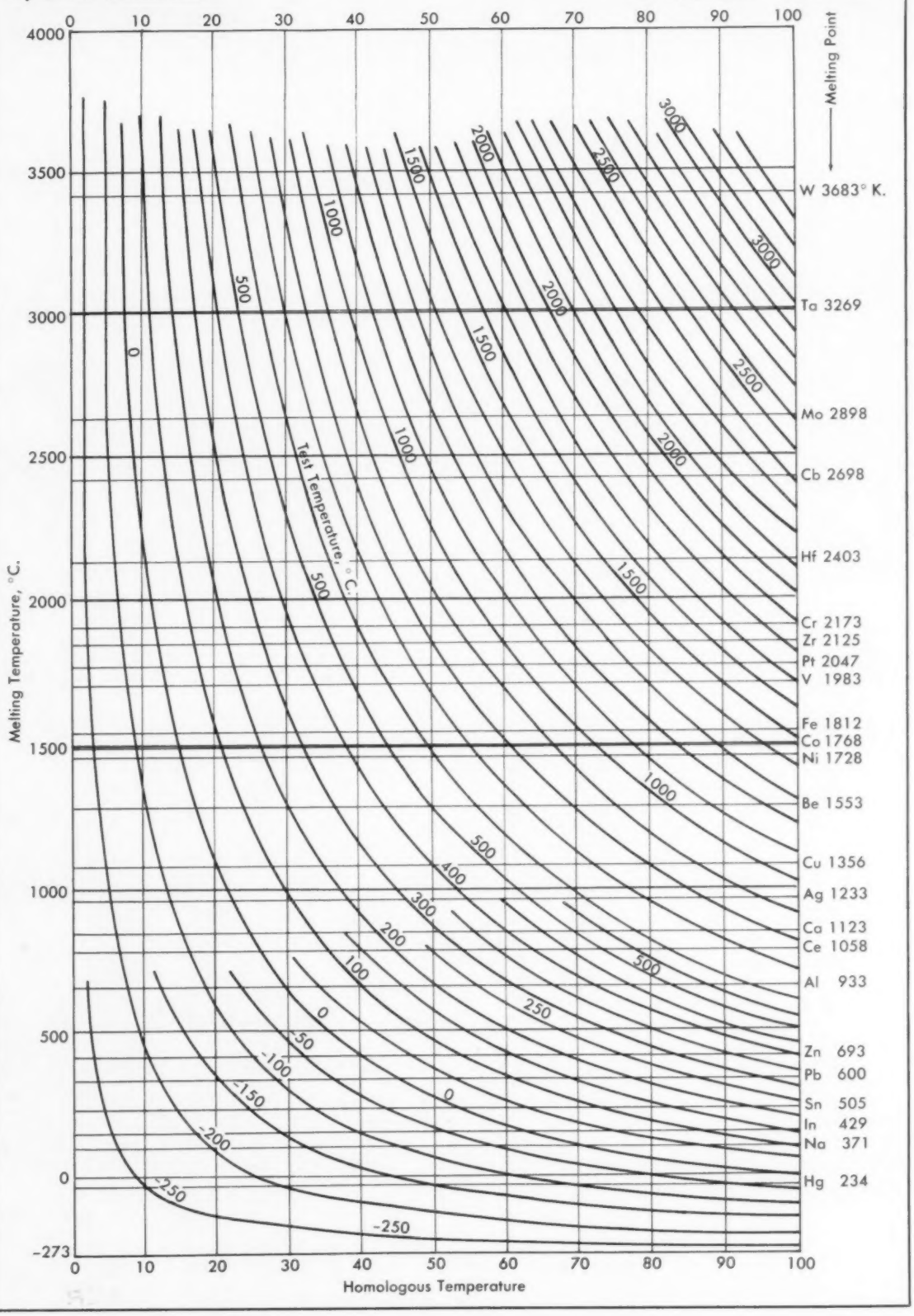
NICKEL MAKES ALLOYS PERFORM BETTER LONGER

A Homologous Temperature Scale for Metals

By J. H. Westbrook

See explanation on p. 100.



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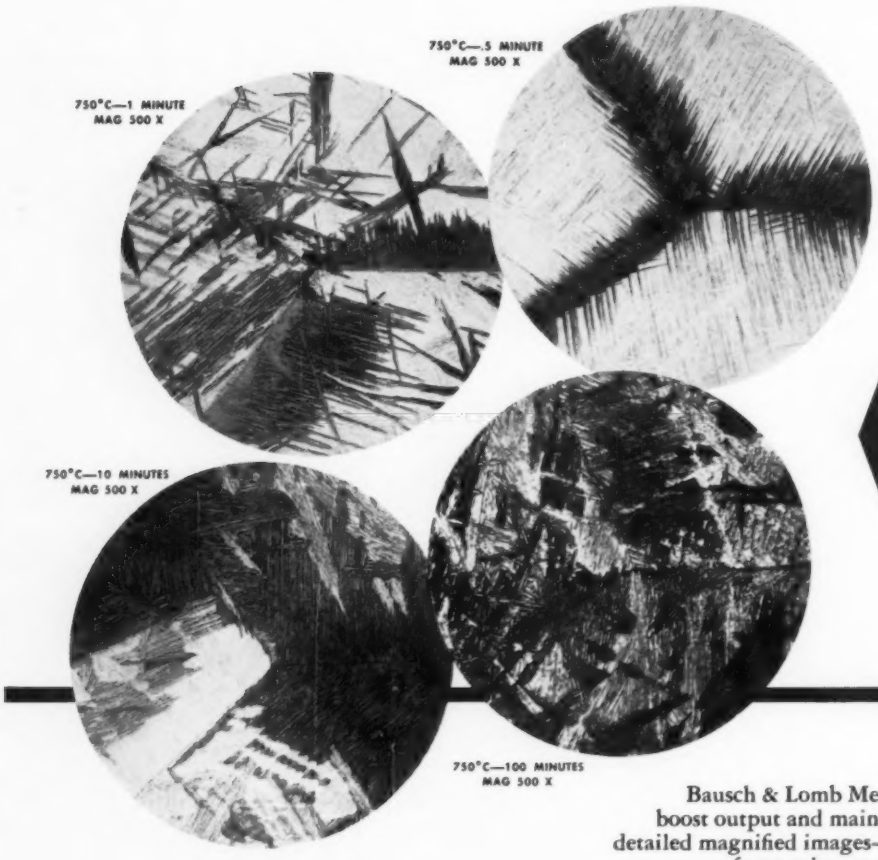

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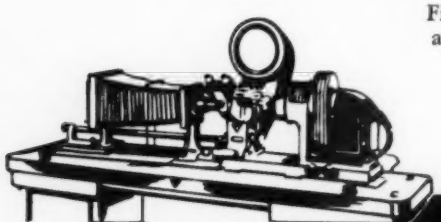

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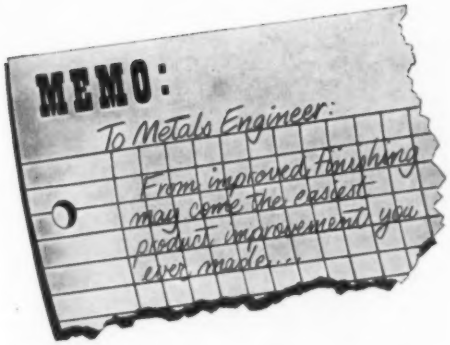


No. 6 in a Series on Better Finishing

Chemical Conversion of Metal Surfaces for Improved Corrosion Resistance

*By ROBERT F. AYRES**

Because it is chemically inactive and possesses low solubility, a conversion coating is a valuable deterrent to corrosion, particularly when it is used as a base for paint. (L14)

CHEMICAL CONVERSION COATINGS are familiar to most manufacturers who use metals which are normally subject to corrosion or which must have surface treatments to aid in deep drawing or break-in operations. As shown in Fig. 1 these coatings are valuable as a base for paints. They also form parting layers for cold working and wear resistance. When unpainted, they are frequently used with oils or waxes for straight corrosion resistance, but occasionally are deposited simply for their decorative effects. Phosphate coatings, chromate treatments, oxide finishes, fluoride complexes, oxalate films and anodized surfaces – all are representative of industrial surface conversion methods which may be selected for use on iron, steel, zinc, cadmium, aluminum, magnesium and, in recent years, on titanium.

It is the purpose of this discussion to survey the fundamental principles of surface conversion reactions, leaving to subsequent articles† in *Metal Progress* more detailed descriptions of specific types and their various uses.

Coatings Form Protective Barrier

The surface atoms or ions of certain metals are capable of reacting with various chemical

*Technical Director, Dunham Chemical Co., subsidiary of Chemetron Corp., Chicago. Mr. Ayres was formerly section head, chemical research department, Oakite Products, Inc., New York.

†In continuing the Series on Better Finishing, *Metal Progress* will present in future issues three more articles on chemical conversion coatings. These will deal with phosphate, chromate and oxide coatings, how they are applied, their limitations and how they are best used.

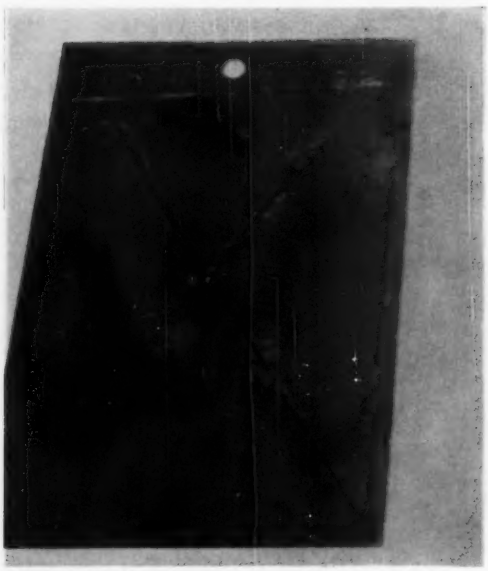
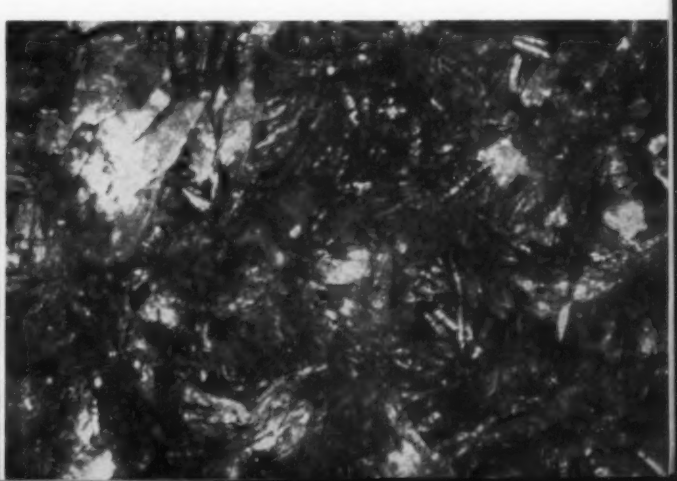


Fig. 1 – Steel Test Panels, Exposed to a Salt Spray for 336 Hr., Demonstrate Why Conversion Coatings Are Widely Used as a Base for Paint. Panel on left was coated with zinc phosphate before being painted. (Photos courtesy Oakite Products, Inc., except where noted)

agents in such a way that solid chemical compounds may be precipitated with the surface. Under proper physical and chemical conditions, the result will be to change or transform the original metal surface so that it acquires a new set of properties which are nonmetallic in character. The layers which are thus developed on the metal constitute what are commonly known as surface conversion coatings. Advantage has been taken of this chemical conversion effect to extend the service life and workability of many metals vital to modern industry.

The possibility of using chemical treatments prior to painting, oiling, or waxing to preserve the common and more sensitive metals from corrosion has stimulated much research in recent years. The application of similar inorganic pretreatments to act as lubricant carriers on a friction surface has also led to extensive investigations. The results have made available a variety of proprietary products and processes which are widely employed to reduce the enormous costs of wear and corrosion.

Fig. 2 – Photomicrographs Show Change in Metal Surface When a Conversion Coating Is Applied. From left: original steel surface; same surface after conversion to zinc phosphate 150×; surface of 52 S aluminum with original mill finish; surface after application of chromate coating, 500×



Surface Properties Changed

The basic idea behind this endeavor is that where the metals themselves may be reactive and subject to corrosion, certain of their salts

and oxides are not. In other words, the surface of a metal may degenerate readily in a given environment, but homogeneous layers of the stable and insoluble oxides, phosphates or chromates of the same metal will remain relatively inert under identical exposure. Since corrosion is primarily a surface phenomenon, changes in the metal surface (Fig. 2) through formation of such oxides or salts can improve surface homogeneity and passivity. This, added to the barrier or shielding effect of the resultant inorganic coating, may retard normal atmospheric corrosion of the parent metal.

In practice the usefulness of conversion coatings is generally enhanced (or supplemented) if they assimilate one or more additional agents. For example, corrosion-inhibiting residues may be left on the conversion surface from dilute chromic acid rinses; co-precipitants may be laid down, as from molybdic or tungstic oxides; sealing of the primary coatings may be accomplished by subsequent hydrating of anhydrous precipitates. In addition, the conversion coatings are almost always used as the base for oils, waxes, stains or organic finishes to yield a synergistic combination on the metal surface.

Chemical Bond Holds Coating to Metal

The chemical conversion of a metal surface is characterized by the development of a precipitate upon the surface, or more accurately by formation of a precipitate *with* the surface. The metallic and ionic nature of the metal at the surface is altered by conversion into nonmetallic chemical compounds through mechanisms in which the metal atoms themselves become components of the compounds. The process of surface chemical conversion is thus the tranformation of the outer atomic or ionic layers of a metal into insoluble chemical compounds of the metal – the result of precipitation reactions.

In forming a conversion coating, the metal itself initiates the reactions, supplying the cationic elements which interact with certain anion-formers in the surrounding medium to produce solid compounds. One of the reactants in the system is necessarily in the solid state, whereas the other reactants are in a fluid state. The physical systems involved in conversion coating reactions consist, therefore, of solid-liquid, solid-gas, or solid-liquid-gas phases. Consequently, the phenomena which take place are concerned with interfacial or phase-boundary relationships.

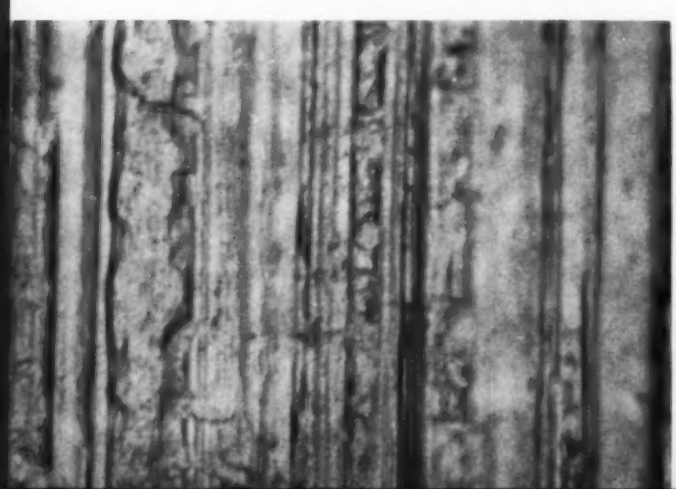
Several somewhat involved theories, each possessing considerable validity, have been derived to explain the intrinsic mechanisms underlying the chemical conversion of metal surfaces. But since the result is the formation of an insoluble chemical compound by interaction between the metal and its environment at their interface, it seems perfectly legitimate to consider the over-all kinetics in terms of special types of precipitation reactions. By so doing, much of the complex mathematical or thermodynamical theory can be eschewed, while at the same time left implicit in the picture.

Special Characteristics Defined

Before developing and illustrating this viewpoint further, it might be well first to consider, in a broader sense, the qualifications that apply to true conversion coatings.

It can be stated that a minimum of five requirements are necessary to delineate a true reaction system for surface conversion. These five provisions, listed below, have the over-all effect of establishing conditions for an irreversible physicochemical process.

- The metal must be surrounded by a fluid such as a mild acid which will render its surface reactive.
- The medium must contain soluble anions or



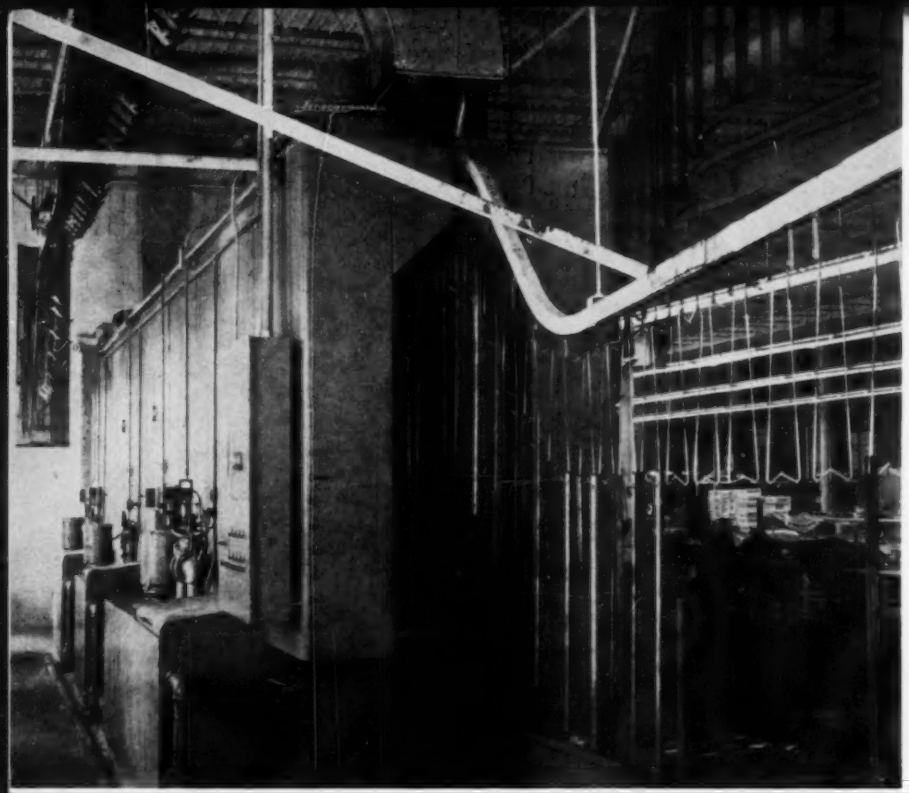


Fig. 3—Three-Stage Machine Cleans and Phosphatizes Steel Racks, Then Rinses Them in Water and Chromic Acid, in Preparation for Painting. (Courtesy Market Forge Co.)

anion-formers* (phosphate, chromate, oxalate, ferrocyanide, oxide, sulphide, dissolved oxygen, colloidal sulphur).

- The character of the medium at the interface must be so changed by the anion-cation interaction (by local reduction of free acidity adjacent to the metal, for example) that it does not dissolve the reaction product.
- The insoluble chemical compound which forms must precipitate sufficiently close to the metal surface so that it remains an integral part of the surface.
- A transition layer must develop across which the binding forces holding the coating to the metal can be exerted.

These conditions merely set up the basic specifications for a conversion coating system and as such they sharply distinguish between deposits upon and conversion of the metal surface. Further qualifications must be made to evaluate surface conversion with respect to sources of reaction energy, inherent protective value, relative stability, and comparison of man-made and spontaneous conversion phenomena.

*The term "anion-former" is used to distinguish between substances that normally exist as true ions in solution such as PO_4^{3-} or CrO_4^{2-}, and dissolved oxygen, colloidal sulphur and the like. The latter are not ionic but may subsequently become anionic members of the compound when a coating is formed.

Anodizing processes and electrophosphating are examples of surface conversion systems in which the driving forces are provided by externally applied electric currents. While these films meet the requirements for conversion coatings, they might best be called electro conversion coatings rather than chemical conversion coatings.

The reaction energies for true chemical conversion coatings are strictly internal and self-contained in the system. The energy sources are chemical or electrochemical in origin, although the reaction rates are frequently increased by the external application of heat. Examples of conversion coating processes in this class include the phosphating of iron, steel, zinc, cadmium or aluminum, the chromate coating of aluminum, zinc, cadmium or magnesium, and the black oxide finishing of steel.

Bond Determines Protective Quality

The stability and protective value of conversion coatings must always be examined in relation to the inherent nature of the compound and its bond with the metal, the type of supplementary treatment it receives, the purpose for which it is designed, and the environment to which it will be exposed.

Of prime interest in understanding the nature of conversion coatings are the transition zones

and the nature of bonding forces between the metal and its conversion layer. In this transition region are the loci of nucleation for the incipient precipitations which initiate the converson reaction and from which the protective quality of the coating is largely determined. It is here also that the metal atoms become tied up in metal compounds, thus forming molecular bonds which contribute the major adhesive forces between metal and conversion coating.

These molecular linkages are more important than any other adhesive forces in holding the coating contiguously with the underlying metal. They create the main distinction between conversion coatings and deposits upon the surface. The latter completely lack the molecular type of union. Both classes, however, may exhibit adhesive properties due to physical interlocking within the outer pores of the metal, electrostatic forces, and attraction of the atoms on the metal surface to the deposit.

The stability and value of a surface conversion system are enhanced if the coating is impermeable and resistant to abrasion, impact and distortion. Its protective value is further increased when the coating is electrically inert and tends to block off electrochemical activity which normally leads to corrosion of the metal. The beneficial effects are strengthened if the coating possesses not only electrical homogeneity, but also imparts physical homogeneity to the surface. Coating reactions must be capable of achieving an irreversible thermodynamic state, at which time no further chemical action takes place; that is, the coating must be "self-stifling". The alternative to "freezing" the reaction is eventual destruction of the coating or its transition areas on aging. This may be manifested by powdering, flaking or peeling of the film, and by continuous disintegration of the parent metal.

Corrosion and Conversion Are Similar

Chemical conversion reactions which are not stopped at some favorable stage become corrosion reactions. This is because the converting of the outer metal atoms into chemical compounds may otherwise continue until all, or almost all, the metal is consumed. The process is also synonymous with corrosion when metal ions can infiltrate through the transition zones causing separation of the coating. Disintegration of the coating occurs if its porosity is such that migration of metal ions brings them to the surface or if diffusion of oxygen through porous layers permits constant fresh exposure of virgin metal to oxidation.

Strictly speaking, those surface deposits which develop as byproducts of corrosion are themselves conversion coatings. Such coatings obviously are not always beneficial to preservation of the metal. The rusting of iron, for example, represents a surface conversion reaction which usually produces a porous coating and establishes an unstable physical and chemical system with the basis metal. It goes without saying that corrosion, or the products of corrosion, can seldom be looked upon as assets. On the contrary, they are sources of an enormous economic loss, and the fight against corrosion is the prime motivating factor in designing surface conversion systems. Those metals which are most susceptible to corrosion are also the most receptive to protection by conversion coatings. The thermodynamic relationships are essentially the same in both reactions.

In ordinary moist atmospheres, spontaneous conversion coatings may develop on many metals. Conversion of the surfaces with uniform tarnish or by formation of homogeneous oxide layers protects certain metals to some degree. Aluminum, an active metal, is a classic example: The atmospheric conversion of its surface to a thin, resistant oxide film causes it to behave as a stable metal. Magnesium is likewise capable of protecting itself against rapid corrosion in most atmospheres, but the resulting discoloration is usually undesirable. Zinc and cadmium also develop a measure of protection by a limited surface conversion in moist air. But these natural oxide films rarely are protective enough.

Basic Concepts of Surface Conversion

In attempting to describe the basic requirements that govern the tendency of a metal to form conversion coatings, it is necessary to consider three fundamental aspects of the physical systems involved. The first is the electron theory of metals; the second concerns natural inhomogeneities in metal surfaces, and the third electrical phenomena at interfaces.

The electron theory of metals postulates, in brief, that a metal may be thought of as an assemblage of positive ions immersed in a cloud of electrons which are relatively "free" to move in the crystal. In this structure, local electrical cells can be set up by electron repulsion, attrac-

tion or discharge at interfaces, in accordance with external conditions.

Natural physical or chemical inhomogeneities in metal surfaces establish local anodes and cathodes over a surface by disrupting the electron distribution pattern. Local cell potentials thus may stem from surface roughness, stress, strains, foreign inclusions, interstitial compounds, defects in the lattice, stacking disorders, dislocations, crystal imperfections and alloy phases.

The electrical phenomena which develop at the interface refer to the phase boundary potentials and electrical double layers which are set up when a metal comes into contact with a conversion bath. The unsymmetrical distribution of electrically charged particles near the phase boundary promotes the conversion reactions.

Figure 4 indicates typical surface irregularities that might influence the electrochemical reactions of a metal surface if it should be exposed to a corrosive medium, or a conversion coating electrolyte. The drawing represents an imaginary initial state of metal, that is, a surface condition which induces the first instantaneous reaction potentials. A metal surface alone, however, comprises only half the system necessary in electrochemical reactions.

When the metal is immersed in a medium containing reactive anions or anion-formers, interfacial electrical phenomena begin to operate, and the surface undergoes a change which immediately puts it into a different electrical state. A fresh situation with revised potentials exists and again reactions result which change the state of the system, and so on. This constant change in condition of the metal surface during the course of a coating reaction is often overlooked when theories of surface conversion are propounded. The local anodes do not – as is frequently assumed – necessarily retain their initial electropositive strength, nor the local cathodes their initial area and location after the first instant of reaction.

Fig. 4 – Typical Irregularities on a Metal Surface Which Promote Either Destructive or Protective Electrochemical Reactions Depending on Environment. In the presence of corrosive media the irregularities hasten breakdown of the metal; in contact with conversion electrolytes, they serve as nuclei for the conversion reaction

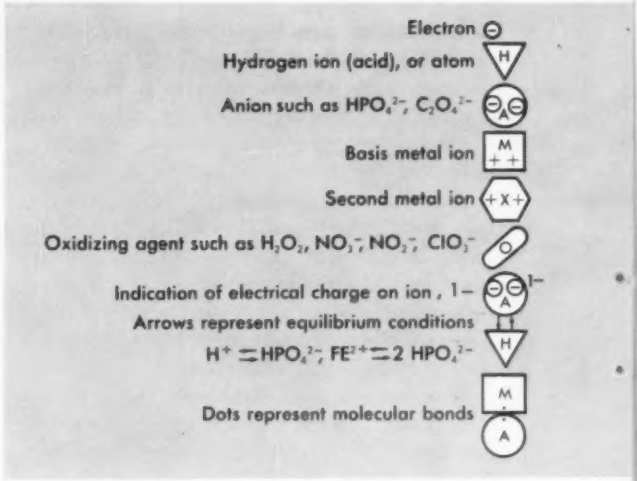
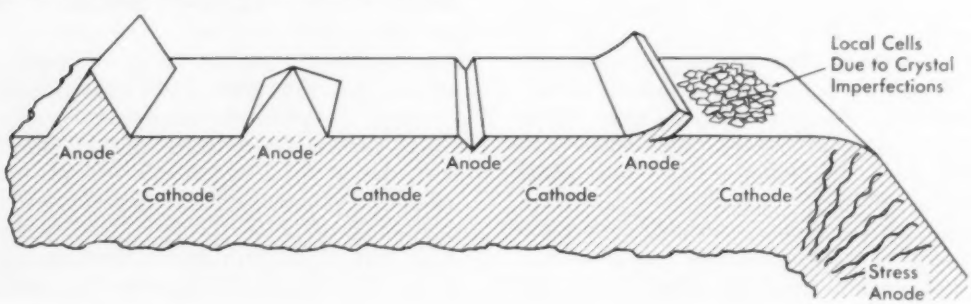
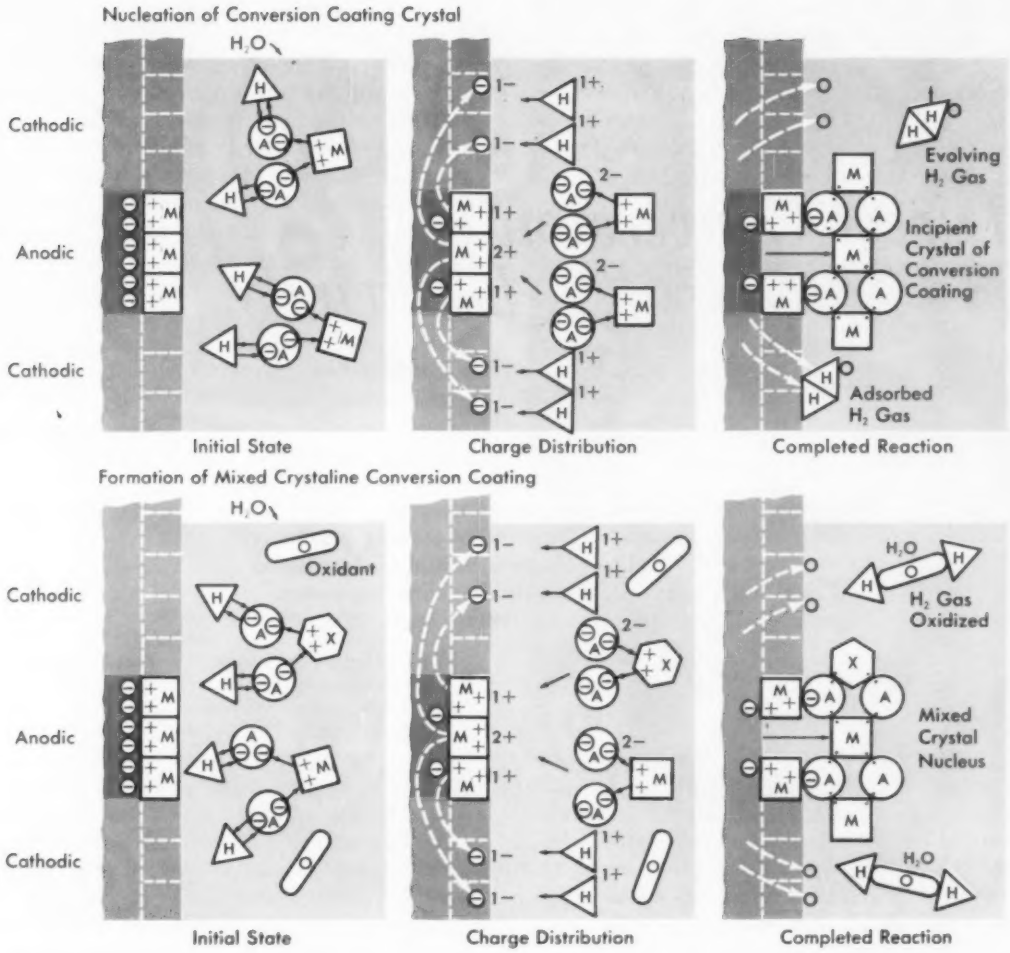

Electron
Hydrogen ion (acid), or atom
Anion such as HPO_4^{2-}, $C_2O_4^{2-}$
Basis metal ion
Second metal ion
Oxidizing agent such as H_2O_2, NO_3^-, NO_2^-, ClO_3^-
Indication of electrical charge on ion, 1–
Arrows represent equilibrium conditions
$H^+ \rightleftharpoons HPO_4^{2-}$; $FE^{2+} \rightleftharpoons 2\ HPO_4^{2-}$
Dots represent molecular bonds

Fig. 5 – Basic Reactions in Chemical Conversion. Reactions continue until metal surface is covered with the protective conversion coating

For simplicity, one might consider several basic reactions as being important in understanding conversion coatings. These include the dissolving of metal by the solution, the precipitation of metal compound (sludge or colloidal dispersion) at a distance from the surface, the nucleation of conversion coating crystals when metal is immersed in a solution of its own ions, and the start of a mixed conversion coating when the metal is immersed in a solution of its own ions plus the ions of a second metal. The latter two are shown in schematic form in Fig. 5. The last example indicates one of the





functions of an oxidizing agent in the system. This is its role as "accelerator" in converting evolved hydrogen to water, thus preventing the gas from collecting on the metal surface where it would slow the reaction rate.

In each of the diagrams shown in Fig. 5 three separate steps are depicted to trace the status of the reaction components from their instantaneous initial state, through the theoretical line-up of interfacial electrical charges, to the final significant phase boundary changes.

It should be understood that the achievement of the final state — the conversion coating — depends on the passage of electrons from the metal across the phase boundary to reduce hydrogen ions and thus remove acid from the reacting system. This gives the reactions local irreversibility at the interface and promotes the fixed position and insolubility of the coating. The chemical inertness then developed by the coating, in contrast to the reactivity of the metal surface itself, stems from the inability of electrons to be further transferred across the solid-liquid interface from the crystalline or amorphous conversion structures.

The processes illustrated by the diagrams can theoretically continue to operate at the shifting anodes and cathodes until the entire metal surface essentially acquires an electrical equilibrium through the formation of a conversion coating. Actually, of course, many thousands of ions are involved at the anodic and cathodic sites on the surface, and growth of coatings can occur by local supersaturation and accretion phenomena over many molecular layers of thickness.

The desired results obviously depend upon properly balanced and properly constituted chemical media. It is in this area that the art and the science come to bear.

Direct Conversion of Nuclear Heat to Electricity

*By W. E. SHOUPP**

Thermo-electric materials, used as an array of series-connected thermocouples, offer an exciting possibility for conversion of the almost limitless heat of nuclear fission into electrical energy. Another direct generating system employs the thermionic method. (W11p, 16-61, 16-62; SGA-a)

As we extend our search for more efficient power generation systems, we find two promising areas for investigation: the temperature of the heat source and materials to withstand higher temperatures. A survey of higher-temperature areas as heat sources discloses that, as temperatures rise, problems become acute, because materials which can operate in the hotter zones are likely to be scarce and expensive.

Equally important is the fact that, as the temperature increases, the types of materials that are applicable are not always suitable mechanically. Typical of those which will withstand these higher temperatures are the ceramics, which generally have low ductility and poor tensile strength.

Therefore, if we are to go to higher temperatures for power generation, the poor physical characteristics of ceramics limit conversion methods to static rather than dynamic systems. This suggests a passive generation method such as the thermo-electric or thermionic system.

*Technical Director, Atomic Power Dept., Westinghouse Electric Corp., Pittsburgh.

Fig. 1 – This Is One Accepted Design of Fuel Element for a Nuclear Reactor. Pellets of uranium oxide (UO_2) are encapsulated in a tube of stainless steel or zirconium

Nuclear Heat Source

Since the nuclear reactor is the prime example of a passive heat source (no moving parts), let us examine its high-temperature possibilities. Outlet temperatures in most water reactor systems are in the 600° F. range. This does not mean that nuclear reactors are inherently low-temperature devices – quite the opposite is true. However, since we are still in the early stages of reactor development, we have not yet developed the materials or technology to take full advantage of temperatures available. But we know that, as temperatures go up, the higher capital cost and increased technical complexity that result can more than offset the gain in efficiency that higher temperatures achieve. While these are big problems today, both will eventually be solved, because this will be required to resolve the economics of these new methods of power generation.

How can the nuclear reactor help in this progress? For the answer, let's examine a typical reactor.

First, consider the fuel element, for it is the fission heat generator. An accepted design is

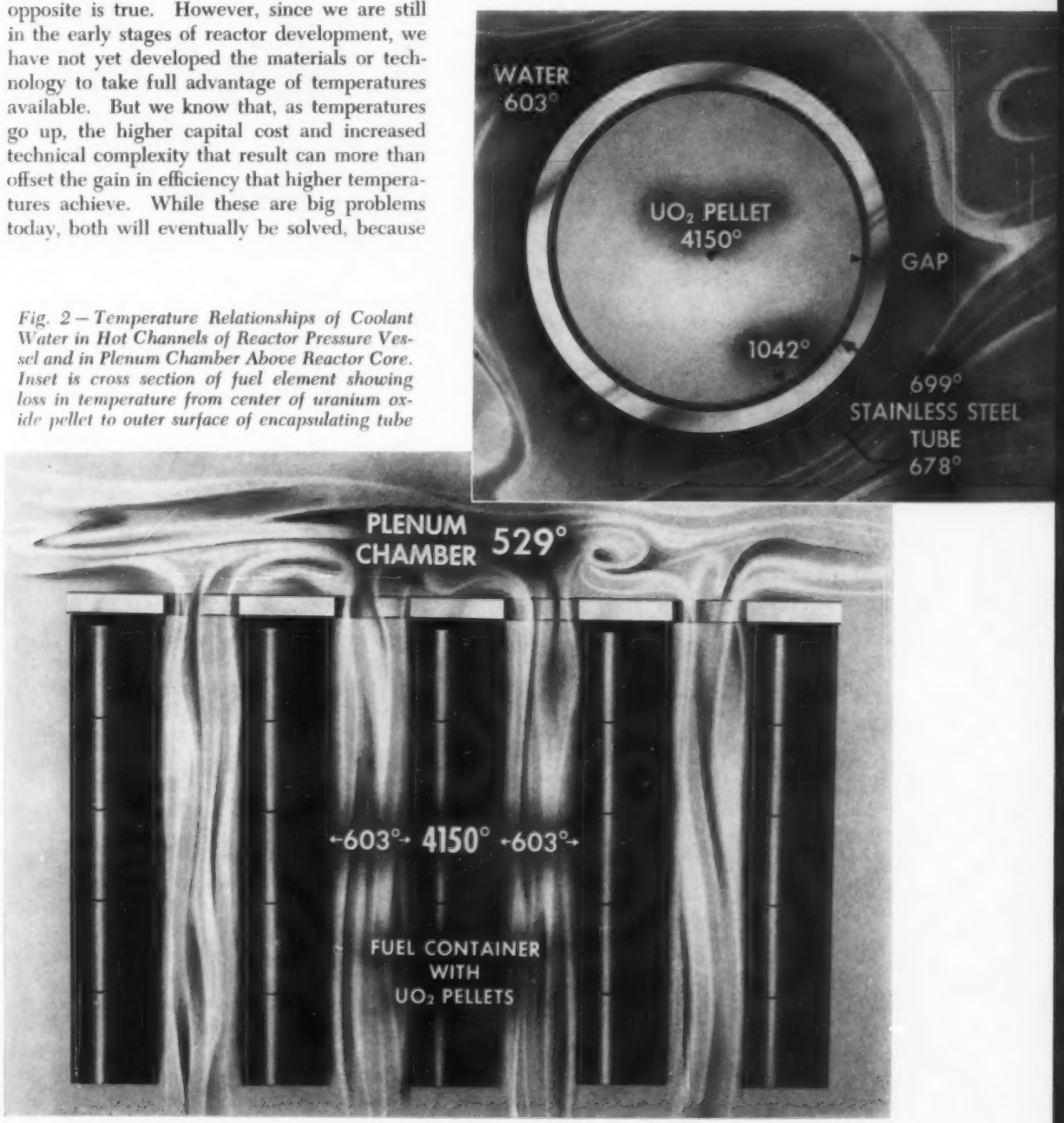


Fig. 2 – Temperature Relationships of Coolant Water in Hot Channels of Reactor Pressure Vessel and in Plenum Chamber Above Reactor Core. Inset is cross section of fuel element showing loss in temperature from center of uranium oxide pellet to outer surface of encapsulating tube

to encapsulate uranium oxide (UO_2) pellets in a tube of stainless steel or zirconium as illustrated in Fig. 1.

The fission process has energy equivalent to about 1000 billion degrees Fahrenheit. We can see then that the fission process does not limit the heat output of the reactor. If we look further, however, we will discover that the low heat conductivity of uranium oxide does limit the heat output. As shown in Fig. 2, the temperature of the uranium oxide (UO_2) in the center of the fuel pellet is 4150° F., which is reasonably close to its melting point of 5000° F. Since uranium oxide has low heat conductivity, a 75% drop in temperature is experienced as the heat is conducted from the center of the pellet to the outside – from a temperature of 4150° F. down to 1042° F.

A second temperature drop brings the usable temperature down to 699° F. This comes about this way: The uranium oxide pellets have a different coefficient of expansion from their encapsulating material. Therefore, since the pellets must be free to move within the tube, a gap between the pellet and the inside wall of the tube is designed into the fuel element. This gap accounts for a temperature drop of 343° down to 699° F. A further drop of 21° is experienced as the heat is conducted through the wall of the cladding material. This brings the outer wall of the fuel element down to 678° F.

The final temperature drop takes place between the coolant water and the outer surface of the fuel element. This drop – film drop, as it is called – reduces the hot channel water to 603° F. The typical reactor has some regions – particularly near the outside edge – that are not as hot as the hottest channel. When this cooler water is mixed with the hottest, the average temperature in the plenum chamber above the reactor core is only 529° F. This is the temperature at which it is used. It is apparent that although we start with a very hot material – above 4000° F. – we do not make efficient use of the high temperatures available.

Conversion With Thermo-Electric Device

We can use the thermo-electric principle to convert the heat of fission directly into electrical energy. The most efficient way to do this is to expose the hot junctions of the thermo-electric device to a hot fuel element in a nuclear reactor and the cold junctions to the moderator-coolant water as illustrated in Fig. 3. Such a design poses a problem in the selection of materials for the thermo-electric device, because the materials must behave properly under irradiation conditions in a reactor. While this places stringent requirements on thermo-electric materials, such materials are available and we are testing a number of them in the Westinghouse Testing Reactor at Waltz Mill, Pa.

Indirect Conversion

To overcome the undesirable effect of radiation on thermo-electric materials, we can go to an indirect method and use as heat source the moderator-coolant water. This requires a boiler which employs thermo-electric tubes instead of regular boiler tubes. It is connected to the nuclear reactor pressure vessel as shown in Fig. 4. The thermally hot, moderator-coolant water flows down the center of the thermo-electric tube and heats the alternate hot thermocouple junctions, while the cooler secondary water flows around the outer surface of the thermo-electric tubes and cools the alternate cold thermocouple junctions and in so doing develops the required temperature difference for generation of electricity.

We believe a thermo-electric generator of the indirect type to be practical in the 1-watt to 10-kw. size and we are building models in this range.

Direct Generator

For thermo-electric generators above 10 kw., our studies indicate that the indirect type becomes cumbersome and inefficient. Therefore, it appears that the direct type – where the thermo-electric elements surround the nuclear fuel (Fig. 3) – will be superior here.

Although the direct-type thermo-electric generator appears most feasible for the larger power generators, there are problems to be solved. One involves the thermo-electric materials. Materials are not available to provide good properties for both hot and cold junctions. Most thermo-electric materials have favorable thermo-electric properties over only a limited temperature range. Therefore, to cover a range of temperatures, a group of materials which possess good thermo-electric characteristics over specific temperature bands must be selected and connected electrically in series. Typical materials which are suitable for cold junction are bismuth-antimony telluride, zinc antimonide, germanium-bismuth telluride, and

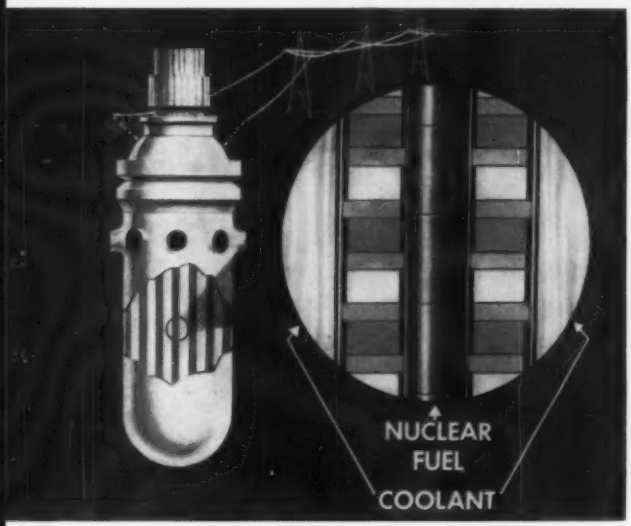


Fig. 3 – In the Direct Method for Conversion, Thermo-Electric Elements Are Wrapped Around Nuclear Fuel Elements to Expose the Hot Junction of the Material to the Hot Fuel Element and the Cold Junction to the Moderator-Coolant Water

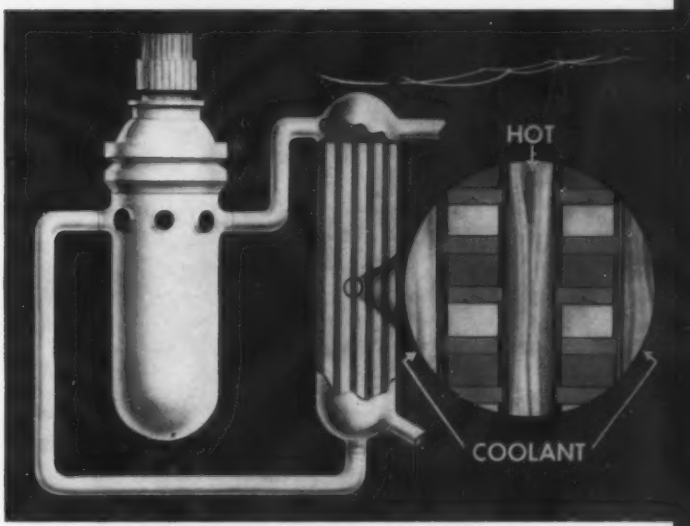


Fig. 4 – To Avoid the Effects of Radiation on Thermo-Electric Materials the Indirect Method of Conversion Employs the Moderator-Coolant Water as Heat Source. This requires a boiler which uses thermo-electric tubes instead of regular boiler tubes

germanium and manganese telluride. Another group of materials suitable for the cold junction includes bismuth-tellurium selenide, lead telluride and indium arsenic phosphide. Other promising materials are nickel oxide containing 3% lithium and sumarium sulphite, which shows good efficiency up to 2500° F. It is indeed a difficult problem to find materials for normal thermo-electric operating conditions, but when the radioactive aspect is added, the problem becomes a major challenge to our scientists.

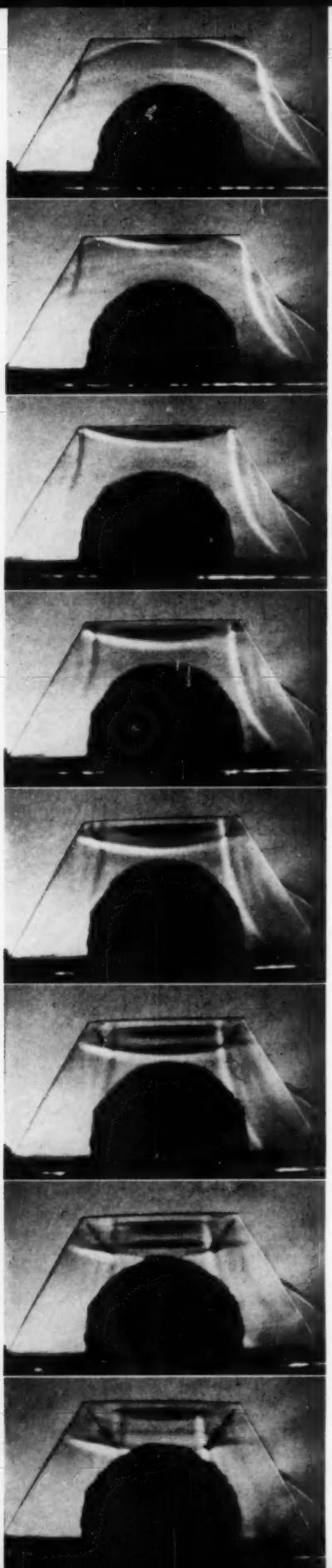
Up to this point, we have talked more about fuel elements than about nuclear reactors as a heat source. One thing which should be mentioned about thermo-electric junctions is the fact that each one generates only a fraction of a volt. Therefore, to make electric power available at usable levels of voltage, a great many of these junctions must be connected electrically in series. This cascading operation is greatly simplified by the fact that reactors have many fuel elements and these can be connected electrically in series to produce reasonably high levels of voltage.

The Thermionic Method

Now, let's look at a different power generating system – the thermionic method. The principle is relatively simple: Apply heat to an electron-emitting filament and the thermal energy extracted from the heat can be converted directly into electrical energy. The filament heat source may be electric power or fission heat. A power generator built on this principle at the Atomic Energy Commission's Scientific Laboratory in Los Alamos, N.M., has been operated for short periods. The hot junction of such a thermionic device is a heated filament which must be an electron-emitting surface. But there is no reason why the heat source cannot be an atomic reactor.

Summary

On a long-term basis, we believe that direct conversion of fission energy through thermo-electric and thermionic generation will become a reality for simple passive systems operating at high temperatures. The realization of this objective depends upon reactor development, and on our ability to develop high-temperature structural and thermo-electric materials. The nuclear reactor offers an ideal heat source for magneto-hydrodynamic and other direct conversion methods. It remains for us to develop the technology and ability to ultilize the high temperatures which nuclear reactors offer us.



Special Report From the West

Explosive Forming and

TWO RELATIVELY NEW, but important subjects occupied the attention of participants at the Monterey Seminar. Sponsored by the Golden Gate Chapter and held April 29 and 30, 1960, this meeting was mainly concerned with the latest ideas in explosive forming and chemical milling. Both topics interest aircraft engineers in the West because each one offers a new and effective way to form the hard-to-shape alloys from which the newer jets and missiles are being built today.

Explosive Forming

This useful, though spectacular, technique is now being extensively employed by the aircraft and explosives industries, along with companies that fabricate parts for missiles. Donald E. Davenport (Stanford Research Institute) stated that "spring back", a common bugaboo encountered in press forming, is overcome by the shock inherent in explosive forming. In fact, many high-strength alloys with relatively low ductility can be formed by explosives, where they cannot be formed on a press. Of help in this, undoubtedly, is the speed with which pressure is applied. Only microseconds, or at best, milliseconds, are needed for forming any part.

Explosive forming is being used to expand symmetrical cylinders and cones of complex, unusual profiles, to punch

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Fig. 1 – High-Speed Pictures of Lucite Shape Undergoing Explosion Illustrate Action of Shock Waves in Causing Failure. At the upper left, shock wave approaches surface of lucite. In subsequent pictures, waves return, and appear to reinforce each other at the corners. Thus, failure occurs at the corners even though the lucite shape is thickest in those locations

Chemical Milling Discussed

*By ROBERT C. BERTOSSA**

These two new methods for forming difficult-to-shape parts are becoming more versatile and more widely used all the time. In this comprehensive report, the latest information concerning each method is given. (G-general, NM-k34, G24b)

flanged parts in metal containers, and to compress metal powders, among other things.

Explosive hardening, for example, deserves some extra comment. Austenitic stainless steels which are not hardenable by heat treatment can be strain-rolled to about Rockwell C-30. In this same application, explosive hardening techniques will give a more uniform and higher hardness of around Rockwell C-38 in plates up to 3 in. thick.

Explosives can also be used to weld, cut, split or engrave metals and alloys. It is interesting to note that satisfactory welding does not occur unless the dissimilar metals being joined are at an angle to each other. For example, researchers at Stanford Research Institute joined copper to steel with a 5000-ft.-per-sec. impulse when the copper was at a 20° angle relative to the steel. The explosive pressure normal to a plate surface can be increased or decreased by varying the angle at which the explosive force is applied.

Characteristics of the Shock Wave

Materials undergoing explosive forces do not break in the same manner as do hydrostatically

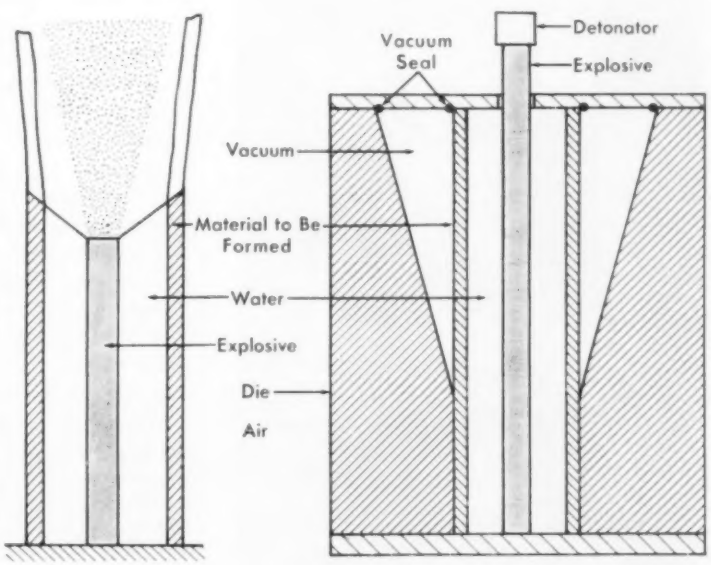
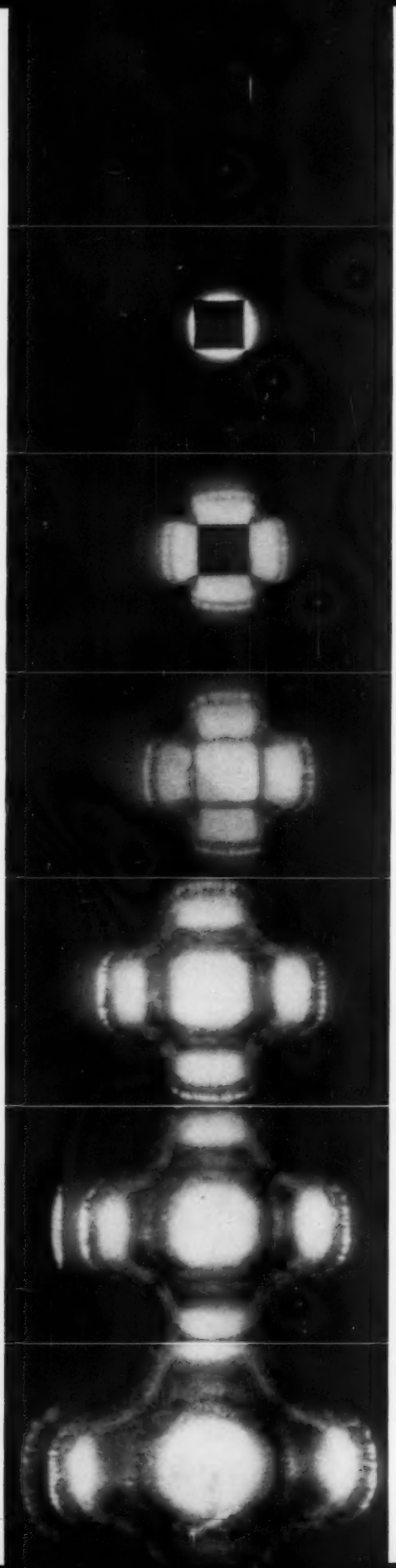


Fig. 2 – Two Examples of Tests Employed in Determining the Characteristics of Materials Undergoing Explosions. High-speed pictures are made when the detonator is fired. In the left-hand test, the cylinder expands freely; in the other, the cylinder is constrained by the die



loaded materials. Contrary to what would be expected, explosive forming causes metals to fail in the thick areas rather than in the thin areas. In extensive studies made of the fragmentation of hand grenades, engineers found that the grenades split along a ridge (rather than along a depression) when they exploded.

This "ridge-cut" theory is shown pictorially (Fig. 1) on a lucite configuration. In the first photograph (taken just as the explosion occurred), shock waves propagate outward from the center cavity. Each succeeding picture illustrates these waves returning from the outer surfaces. Because of the shape of this piece, the returning waves appear to intersect at the corners where the lucite piece is thickest. Finally, in the last four pictures, cracks can be seen bisecting the angles at the corners, causing the thickest sections of the shape to fail.

"Spalling" is another characteristic which explosions can cause in metals. If a heavy charge is detonated on one side of a relatively thick metal plate, it can set up shock waves which are severe enough to spall off layers on the *opposite* side of the plate without failure on the side which receives the impact of the explosion.

If one wishes to form materials by explosion, he must know how the particular alloy behaves under various explosive conditions. To determine this he generally uses a test cylinder of the material filled with water, and with an explosive core down the middle. (The test setup is sketched in Fig. 2.) Explosion conditions are studied with a high-speed camera to derive the characteristics of each particular metal or alloy.

In forming sheet to a controlled contour or shape, outside dies can be used as shown at the right of Fig. 2. Notice that the assembly is made so that a vacuum exists in the space between the cylinder and the die. The vacuum is required because any gas between the die and the parts will compress and interfere with forming. Since such gases can also heat up to as high as 10,000° F. in an extremely short time, they may scorch or melt the metal part as well.

Fig. 3 – High-Speed Pictures Showing a Square Charge of Explosive as It Detonates. Note that most of the force is expended perpendicular to the faces of the square. When complex parts are to be shaped, the charge can be designed accordingly

When water is used (instead of air) to transmit the shock, pressure falls off more slowly as a function of distance. The table below gives an idea of the values involved.

Medium	Time After Detonation	Pressure Peak
Water	1 min.	40,000 psi.
	3	10,000
	5	5,000
Air	1	5,000
	3	0
	5	0

Effect of Explosive Shape

The shape of the charge also has an important bearing on the effect of the explosive. Shock waves moving out parallel to a face of the explosive are much greater than those moving at angles. This characteristic is useful in controlling local pressures, and also can be used in contour forming the more complex shapes.

Figure 3 shows a series of high-speed photographs of a square stick of explosive as it detonates. These photographs clearly illustrate the much greater intensity of the shock waves moving out parallel to each of the four faces.

In predicting the future for this process, Dr. Davenport emphasized that ". . . although explosive forming techniques already show great promise as an industrial tool, considerably more scientific research is needed in this field before the full capabilities and potentials for this phenomenon will be realized".

Chemical Milling

Chemical milling was discussed by F. L. Bailey (president, Chemical Milling International Corp.). This unique method for producing structural shapes through the selective removal of metal by chemical etching was developed at North American Aviation in 1953, and is now licensed out to many aircraft and missile organizations in both the United States and Europe. Though only aluminum, magnesium, titanium and stainless steels are chemically milled in general practice, the process is said to be applicable to almost any metal or alloy.

According to Mr. Bailey, chemical milling is the most efficient and economical method of selectively removing weight from materials. As an example of its value in the B-70 program, removing 0.001 in. of excess material on the entire plane amounts to saving one full ton of weight. Over 6000 parts on the B-70 require chemical milling. Since it costs around $1000 per pound of weight to put a satellite into orbit, it is easy to see that such savings are vitally important.

Some of the more salient characteristics of chemical milling are given below:

- An intricate part can be formed first, then the excess weight can be removed where it is found unnecessary for structural strength.
- Metals can be chemically milled while they are in the fully heat treated condition without affecting the heat treatment. Also avoided is the warpage which can occur when parts are heat treated after finish milling.
- Parts can be chemically milled to tolerances as close as ± 0.002 to 0.003 in.
- Surface finishes of 20 to 50 rms. can be obtained in milled areas.
- Sheets can be inexpensively tapered through their thickness, either on one or both sides. Tapering in two directions at once is possible through proper immersion technique.
- Entire sheets can be readily reduced in thickness. In this application, no masking is required.
- Fabricators can produce complicated structures in integral form without the necessity for welding or riveting various thicknesses together.
- Tooling is inexpensive; only an accurate templet is required.
- Many alloys which are extremely difficult to machine by ordinary methods can be handled quite easily by this process.
- Stainless steel honeycomb can be contoured to close tolerances.

Intricate shapes are readily fabricated. As an example, Fig. 4 shows a contoured missile section which has been chemically milled so that ribs remain for structural strength. The edge of this section is designed to be thicker so that the part can be more easily welded.

Problems in Chemical Milling

Of course, all is not beer and skittles. Like other new developments, chemical milling has its problems as well as its advantages. Heat treated parts, as an example, are apt to spring back when they are milled on one side only. Though chemical milling does not induce stresses, it will sometimes release locked-in stresses to cause warping. In many instances this problem has been solved by adjusting milling techniques, heat treating between stages,

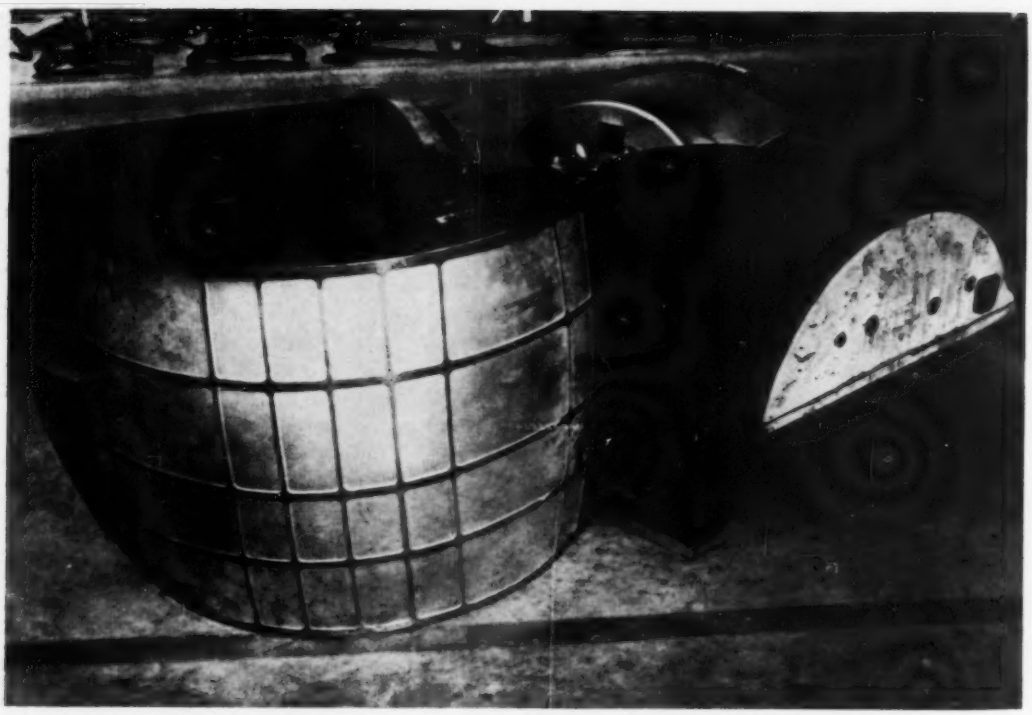


Fig. 4 — A Typical Part as Chemically Milled. The thick edge which remains facilitates subsequent welding

or re-forming between steps. However, about 10% of the shapes milled under these conditions do show some slight contour changes after milling.

"Thinning out" is another drawback even though etching removes material uniformly in all areas. In some formed parts, certain areas may have been thinned previously. This prior thinning must be considered in chemical milling, and various techniques (interstage masking, for example) are needed to prevent further thinning in these areas.

When milling steel and titanium, hydrogen embrittlement has been known to cause problems. By changing milling solutions and improving techniques, this condition has been overcome in milling most titanium and steel alloys. Some alloy steel parts are baked for 3 hr. at 300° F. after milling to remove hydrogen. One alloy which still remains a problem with regard to hydrogen embrittlement is the 8% Mn titanium alloy.

When certain parts are masked for milling, undercutting must be taken into consideration because the solution will etch equally in all directions. To overcome this, the templet is designed to overmask the part for the calculated depth of the undercut.

Etchants for Milling

For aluminum, the most common etchant is caustic soda (NaOH) plus some additives which give a smooth surface. The etching temperature is 100° F. Magnesium can be milled with mild solutions of acid. The etching is usually done at ambient temperatures; however, the solution is occasionally refrigerated to slow down the reaction. For titanium and stainless steels, strong acid solutions are used, usually at around 140° F.

As for costs, the following observations were made:

- Usually, work done by chemical milling is that which is not machinable by ordinary methods. (Where conventional machining can also be done, chemical milling cannot always compete from a price standpoint.)
- Where relatively shallow cuts must be given over large surface areas, chemical milling is probably the cheapest method.

Fig. 1 — Arresting Hook of S2F-1 Tracker (Shown Here Extended From an Aircraft During a Carrier Approach) Posed Unique Problem in Alloy Selection and Fabrication. Its design called for an alloy of high strength and low magnetic permeability

"K" Monel Solves Arresting Hook Problem

*By ALBERT R. MEAD**

Special electronic equipment in the tail section of a carrier-based aircraft dictated that its arresting hook be fabricated from a nonmagnetic alloy of high strength. (T24d; Ni-b, 17-57)

OF THE MANY DESIGN PROBLEMS unique to naval aircraft one of the most critical is that of the arresting hook. Its task is to snag a wire stretched across the flight deck of an aircraft carrier thus bringing the airplane to an abrupt but safe stop. Some of the landing shock is taken up by playing out the wire, but most of it is absorbed through the arresting hook. Loads on the tail section are tremendous since today's fleet aircraft weigh more than 10 tons and land at over 100 miles per hr.

To engineers at Grumman Aircraft the job of designing and fabricating arresting hooks is an old one. But a new problem came into the picture when Grumman conceived the S2F-1 Tracker (Fig. 1), currently our fleet's first-line antisubmarine plane. Not only must the tail

*Staff Engineer, Manufacturing Engineering Div., Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.

hook of this aircraft meet the usual stringent strength requirements; it must also be nonmagnetic.

Designed to locate, track and destroy submarines, the S2F carries an electronic device known as MAD (magnetic airborne detection) gear. Operation is based on its ability to detect and amplify small changes in the earth's magentic field, caused, for example, by a submerged submarine. To keep the magnetic device at high efficiency, all large pieces of the tail structure must be made of a nonmagnetic material.

Alloy Selection Limited

This requirement places a serious limitation on the number of alloys which can be considered for the job. Aluminum has an excellent strength-to-weight ratio, but flash-welded aluminum components in the tail hook assembly cannot take the high stresses which are imposed. Beryllium copper can be heat treated to high strength and can be flash welded, but it lacks sufficient ductility at the strength level required. Stainless steel meets all the requirements but one; a substantial portion of the strength due to cold work is lost in the welded zones. Turning to alternate methods of assembly other than welding results in excessive weight.

"K" Monel (an alloy containing about 66% Ni, 30% Cu and 3% Al) was approved as the final selection because of its good flash welding characteristics, excellent corrosion resistance, good reproducibility of properties in forgings and its nonmagnetic nature. Permeability at 200 oersteds is 1.0019 when the metal is cold reduced 20% and aged.

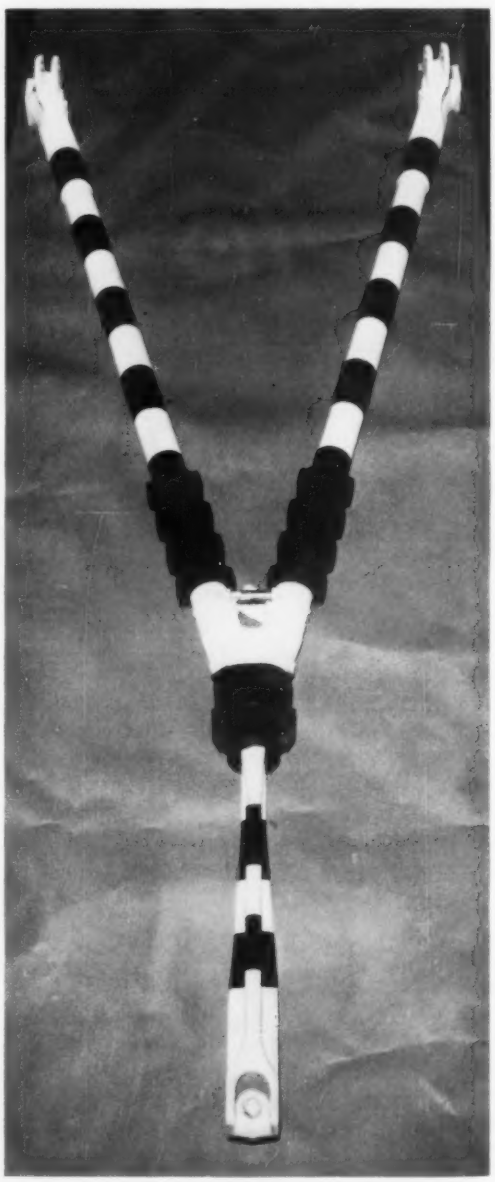
The tail hook assembly is made up of forged and tubular parts joined by flash welding. Forgings presented no great problem and guaranteed minimum mechanical properties were consistently met. Average strengths were:

	As Forged	After Aging
Tensile Strength	100,000 psi.	145,000 psi.
Yield Strength	60,000	115,000
Elongation	30%	21%

Tubular sections, however, proved the more difficult problem.

"K" Monel obtains its final hardness from a combination of cold work and subsequent age hardening (Fig. 3). Since weight is of paramount importance, it is imperative to design close to the maximum possible strength and hardness level which can be obtained consistently during long production runs. Tests at Grumman and International Nickel's plant in Huntington, W. Va., the tube supplier, made possible a specification setting forth the minimum hardness for unaged tubes which would give desired strength and hardness required after aging. It was decided that all seamless tubing must be sufficiently cold worked (about 35% reduction) so that during aging the follow-

Fig. 2 – Arresting Hook for S2F-1 Is Made From "K" Monel Forgings and Cold Worked Tubular Parts Which Are Age Hardened After Assembly



ing properties would be developed: 150,000 psi. tensile strength (minimum), 120,000 psi. yield strength (minimum), and at least 5% elongation. The tests pointed out that hardness readings are not accurate indicators of strength. Differences as high as 9000 psi. for an identical hardness were recorded.

Although a minimum hardness was established as a specification for all cold drawn tubing, it was still necessary to perform tensile tests on aged samples from each lot. Using these test data, we were able to account for any variations in strength between lots of tubing by machining the wall thickness to that cross-sectional area needed to carry the load. Individual testing of each lot of tubing is particularly important because the arresting hook contains a necked-down section which is designed to fail before the stress reaches a level

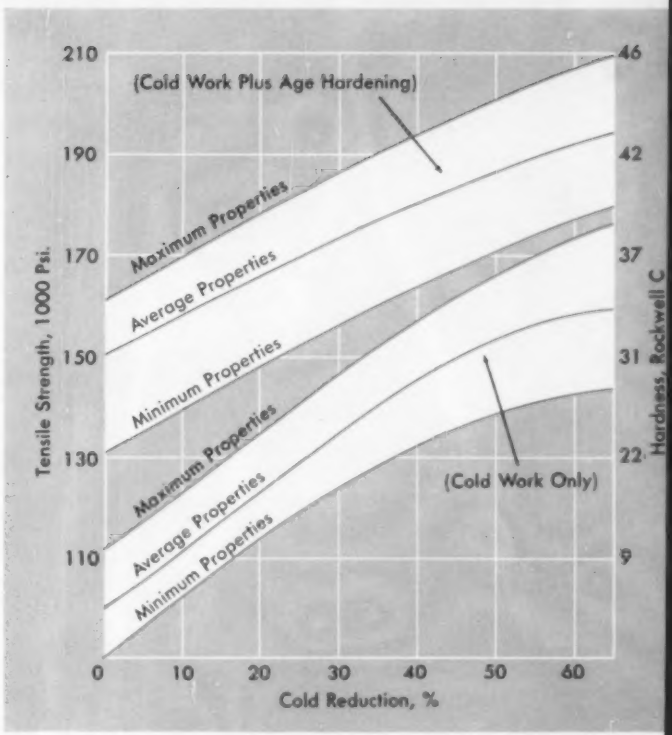


Fig. 3 — Effect of Cold Work and Age Hardening on Tensile Strength and Hardness of "K" Monel. In practice, hardness proved to be an unreliable indicator of strength. Aging was carried out at 1080 to 1100° F. for 16 hr.

Fig. 4 — Inspection With Ultrasonic Equipment Spots Defects and Checks Wall Thickness of Tubing for Arresting Hook Assembly

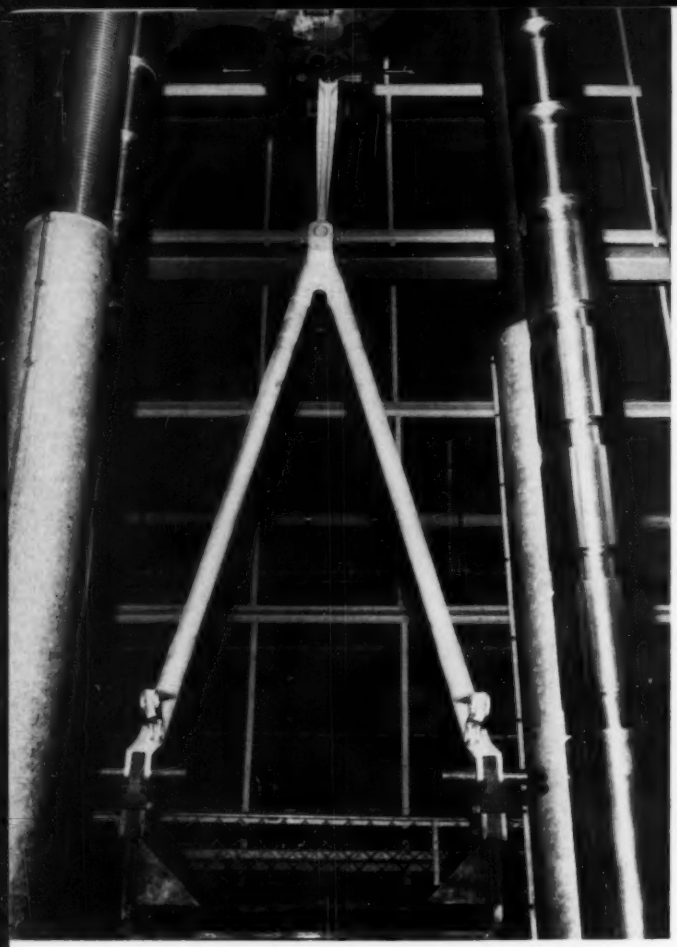


Fig. 5 – Rig for Proof Testing Completed A-Frames. All assemblies are tested by first applying a static load of 70,000 lb. to each leg, then a 70,000-lb. symmetrical load to the assembly

where the tail section would be damaged. If the necked-down section is too strong, the tail section may be torn from the aircraft.

To insure that all parts of the hook assembly were given the optimum heat treatment, a study was made to correlate heat treatment time (6 to 16 hr.) and temperature (980 to 1100° F.). This study permitted us to specify a particular heat treatment – 16 hr. at 1080 to 1100° F. followed by a furnace cool to 900° F. at 15° F. per hr., and further cooling in air or in the furnace – which guarantees that all the components in the hook A-frame, when heat treated as an assembly unit, will be stronger than the guaranteed minimums. Although the time at temperature may seem long, it has actually resulted in cost savings by giving us a lower rejection rate. The procedure hardens the tubular sections to Rockwell C-35 to 40 and the forged parts to Rockwell C-30 (minimum). Cold worked and aged tubes range from 160,000 to 180,000 psi. tensile strength; minimum elongation is 10%.

Because of the critical nature of the tail hook, it is necessary that welding be of excellent quality. Our experience indicates that for best welds high-sulphur cutting oils must be thoroughly removed before welding, purging gases must be of low sulphur content, and the structure must not be overheated during welding.

Inspection Improves Performance

The importance of surface condition and wall thickness of tubular members was demonstrated well after the production technique was established and many tail hooks were in service. The first factor, that of inside surface condition, was brought to our attention when in two separate incidents one leg of the arresting hook A-frame broke during carrier landings. The remaining leg in each instance took the load and both aircraft were stopped without damage. Analysis of the fractures indicated that laps were their prime cause. Two partial failures during many thousands of arrested landings is certainly an excellent record. We decided, however, to hone the I.D. of every tube so that no other arresting hook went into service with the possibility of a lap being present. Honing is followed by a thorough visual inspection and an ultrasonic check (Fig. 4) which also measures the wall thickness.

The second problem was variation in wall thickness greater than permitted by blueprint specifications. Originally tubing was machined on a standard lathe with the chuck gripping the O.D. of the tube. Combined with the 10% eccentricity permitted by tube specifications, this chucking method often resulted in finished parts with walls that were too thin. The improved practice which is now used is to grip the I.D. This results in concentric tubing.

After final fabrication, the almost-completed A-frame is age hardened. Final machining is carried out and the assembly is then proof tested. This test includes a 70,000-lb. static pull on each leg followed by a 70,000-lb. symmetrical pull on the assembly. Figure 5 shows the A-frame being symmetrically loaded.

Since the arresting hook is designed to withstand a high percentage of limit load, its service inspection requirements and replacement criteria are severe. The excellent record of the S2F arresting hooks has made possible a significant extension of the service life and the period between inspections.

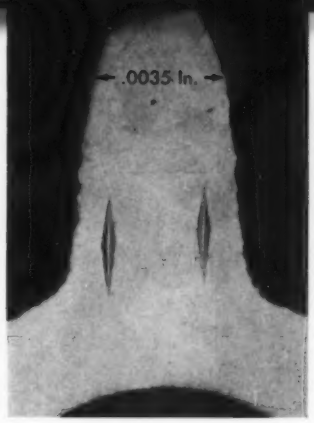


Fig 1 — Microhardness Impressions in One Tooth of a Minute Watch Pinion, 0.0288 In. in Diameter. Magnification, 250 ×; load on indenter, 300 g.

Where to Use Microhardness Testing

*By VINCENT A. LYSAGHT**

Not merely a laboratory technique, microhardness testing has definite industrial potential. The method can be used in testing small parts, thin sections (sheet and wire, for example), and hardness near edges of cutting tools. Hardnesses of microconstituents and small areas can also be determined. A number of applications, both in the laboratory and in the shop, are described in this article. (Q29q)

IN AN ARTICLE IN *Metal Progress* last month microhardness testing was discussed from the standpoint of available equipment, along with the characteristics and limitations of the test. Now, we will cover applications of the test, both present and potential.

By no means is the art confined to measuring the hardnesses of microstructures. The technique can also be used for testing thin sheet materials (0.0005 in. or less), fine-diameter wires, extremely small precision parts, hardness gradients in superficially hardened surfaces, hardness variations in small areas and in shallow electroplated surfaces, and hardnesses of different constituents of metals. Since applications for microhardness testing are manifold, it would be impossible to discuss all of them. However, we can sort them into six categories:

1. Small precision parts
2. Surface layers
3. Thin materials and small wires
4. Exploration of small areas
5. Hardness of constituents
6. Hardness near the edge (toolsteels, tips of cutting tools, and the like)

Small Precision Parts

It is often important to know the hardness of watch parts and other small precision items. For testing, such parts should be mounted in a thermosetting plastic, and polished like metallographic specimens. Since the size of the indentation can be varied by changing the load, every type of watch part, even the smallest, can be readily tested. For example, hardnesses have been determined for balance staff pivots, screws, pinions, studs, pins, click springs. Figure 1 shows Knoop indentions made with a load of 300 g. on a small pinion.

Surface Layers

Knoop hardness gradients through carburized steel cases and induction hardened parts can be invaluable to the metallurgist as Fig. 2 illustrates. Both the hardness gradient and the photomicrograph of the section are shown.

*Wilson Mechanical Instrument Div., American Chain and Cable Co., Inc., New York. This is the second of a two-part article; the first appeared last month.

In industry, a common practice is to specify case depths of 0.015 to 0.020 in. with the surface being ground after heat treatment. As a consequence, if only 0.010 or 0.012 in. is removed, it is possible to go below the zone which has the highest hardness. Even examination at high magnification might fail to determine this, since it is often difficult to distinguish between martensite and tempered martensite when there is a difference of only 3 or 4 numbers on the Rockwell C scale.

On extremely thin cases, such as obtained in cyaniding or electroplating, the microhardness tester is also very useful. Because the case is so shallow, it is important to know the effective case depth. The hardness in the transition zone can give this information. (It should be stressed that a specimen is mounted to provide a means for holding it during surface preparation. Many cyanided parts need not be mounted. Likewise, metallographic finishes are not needed if loads of 200, 300 and 500 g. are used.)

As another example of industrial use, on induction hardened parts a survey of hardening depth can be obtained with the microhardness tester. Then the heating cycle can be regulated.

As for electroplates, satisfactory measurements of hardness of chromium plates 0.0005 in. thick have been made. The base metal had no apparent effect on the determinations. Other plated surfaces (electrodeposits of cadmium, silver, zinc, copper and nickel, for example) have also been tested.

Thin Materials and Small Wires

It is logical to test thin materials through the use of light loads with either type of indenter. Sheet metals down to 0.001 in. or less in thickness may be tested. Microhardness testing is also very helpful in evaluating the work hardening of small-gage wires. Furthermore, hardnesses on a cross section are very reliable indicators for the degree of cold work and accompanying tensile strength.

In making such tests, the worker must be careful not to use too large a load. Otherwise, the remaining material at the edges will not support the load, the sides will bulge, and the reading will be erroneous.

Exploration of Small Areas

Hardenable steels and nonferrous alloys which have been resistance welded can serve as an example of the use of microhardness tests for surveying small areas. A suitable section is polished, and a precise hardness exploration is made at intervals of approximately 0.002 in. across the entire heat-affected area. The hardness gradient in a weld (which is caused by the wide temperature range – from room to melting) varies depending on the size of material welded. Changes in structure can be readily

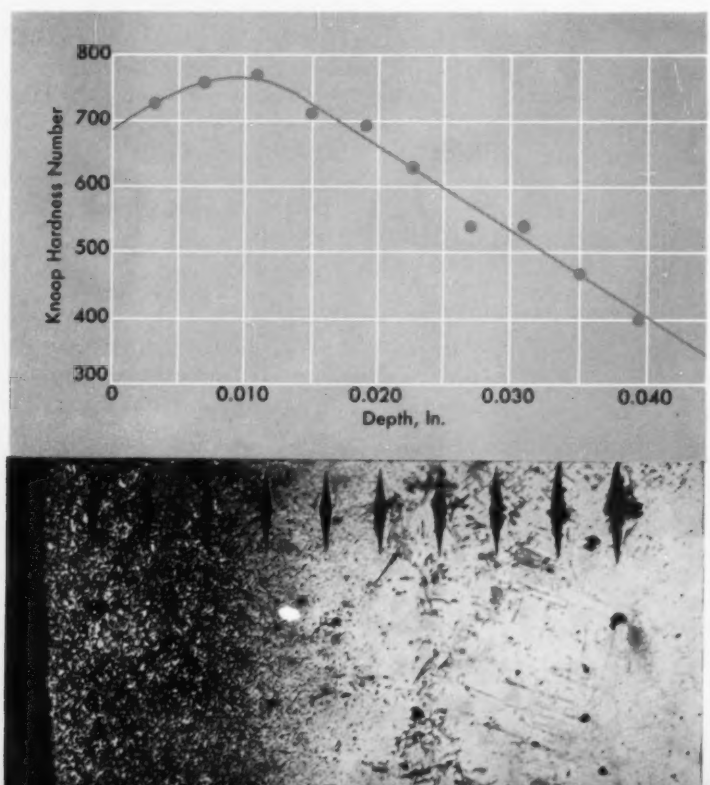


Fig. 2 – Typical Hardness Gradient Determined by Microhardness Test. When both the gradient and the photomicrograph are shown, the metallurgist gains much information concerning the nature of the case. Magnification, 100 ×; load on indenter, 1000 g.

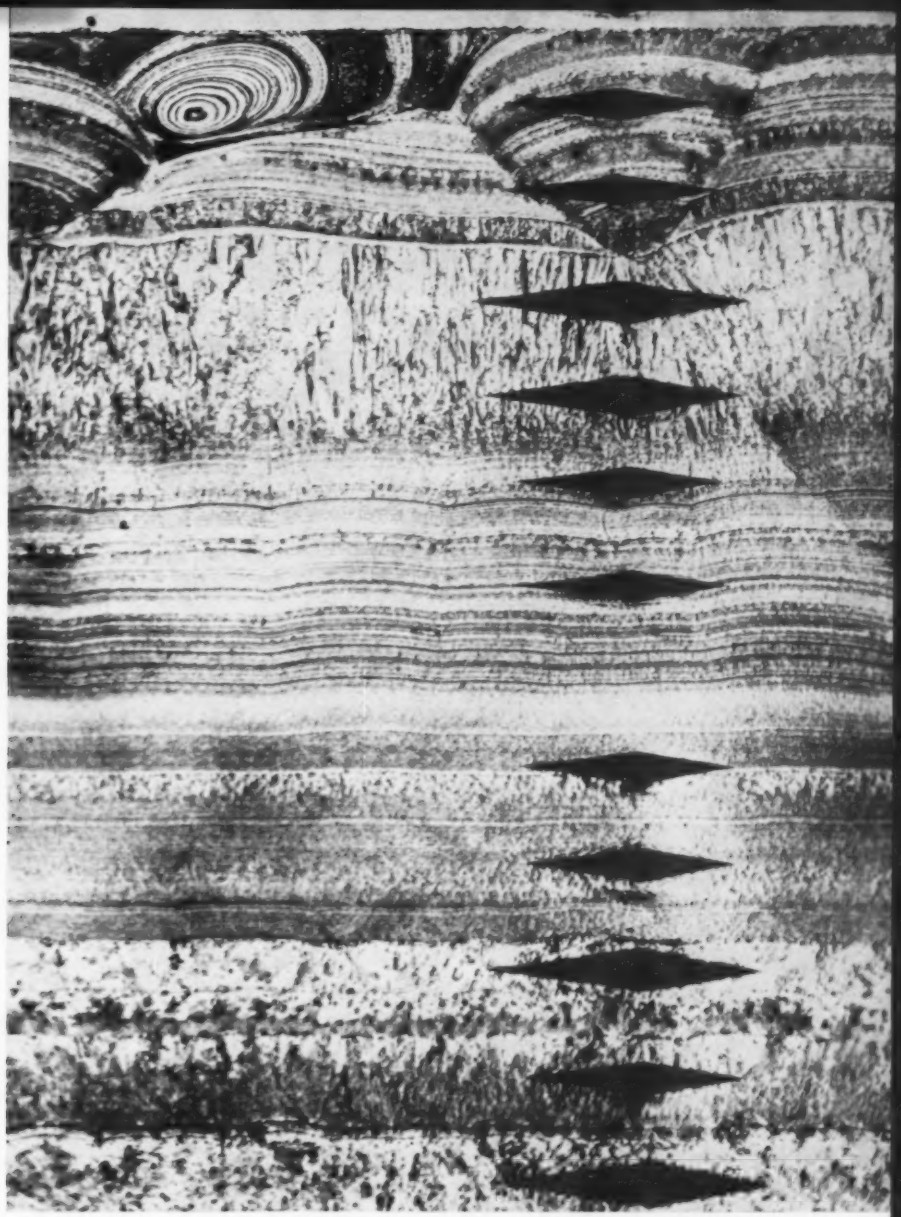


Fig. 3 — This Illustrates the Entire Wall Section of a Copper Cone. Several layers of copper are deposited electrolytically; microstructures and hardnesses vary from layer to layer. Magnification, 250 ×; load on indenter, 100 g.

correlated with hardness over the entire heat-affected zone.

As an example of testing small areas, consider the test performed on a copper cone section by the Picatinny Arsenal, Dover, N. J. The unusual photomicrograph, Fig. 3, taken of the entire wall section of the cone, shows the variations in microstructure and the Knoop impressions which were made in the several layers of electrolytically deposited copper. An indenting load of 100 g. was used. Knoop hardness of the smallest indentation is 168; for the largest, 87. Original magnification is 250 ×.

Another example of small-area surveys is the hardness change variation resulting from grinding burn in hard steel. Sufficient microhardness tests have been performed to show that they are reliable for studying burn in a quantative manner.

In an entirely different application, a Midwest manufacturer tested the hardnesses of metallic sections of chips and machined surfaces under various conditions. Exceptionally large increases in Knoop hardness were observed. Under certain conditions, the fragments of the built-up edge, shed along the path of the tool on the finished surface, were found to be comparable to the hardness of the cutting tool itself. These tests were useful in analyzing the machinability behavior of a metal, and in

correlating that behavior with the physical properties of the material.

Hardness of Constituents

When using the microhardness test for studying individual constituents of a microstructure (such as carbides in a toolsteel, for instance), either the Knoop indenter or the 136° diamond pyramid indenter may be used, depending upon which shape is more appropriate.

Hard spots, encountered when milling high speed steels, led to a typical experiment. These spots were primarily caused by tremendous heat which developed when the cutting tool failed. Metal would "load" or build up in the chipped area and insulate it against the application of coolant. Hardness of the spots, along with the microstructure, showed that local heat, developed in this area, appeared to have reached about 2000° F.

Figure 4 shows how microhardness testing may be applied to determine the hardness of structural areas in a lead-antimony alloy. A 25-g. load was used. The light-colored area (Knoop hardness, 5) consisted of nearly pure lead and large particles of antimony. The darker area is a solid solution of antimony in lead; it has a Knoop hardness value of 10.

Hardness Near the Edge

Hardnesses at and near cutting edges can be readily measured if necessary. Figure 5 shows how the teeth of a saw may be tested close to the cutting edge. In mounting, saw teeth are interlaced to prevent edges from rounding when the sample is polished. In another example, indentations were made in the transverse web and shank section of two No. 80 drills (0.0135 in.) mounted in steel and plastic.

A few years ago microhardness testing was introduced for production control of thin metal. The General Plate Div., Metals & Controls Corp., uses a Tukon Model FB for controlling the hardness of their thermostat metal. Bimetal strip is also tested. The largest percentage of bimetal material is in nickel steels and nickel-chromium steels of equal thicknesses. Alloys such as brass, stainless steel and silicon bronze are also combined into thermostat metals.

In production, these metals are bonded together in slugs 1⅛ to 2¼ in. thick, which are rolled into thin strips to a minimum over-all thickness of 0.003 in. (Experimentally, these same slugs have been rolled to 0.0005 in.) The hardness test is an indication of both the forming qualities and the control of the yield point. It is also a final check of the annealing and reduction processing cycles. The DPH indenter is used, and the load is varied according to the thickness of the metal under test. Considerable laboratory testing was performed to determine the correct load needed to test only each individual layer of metallic strip. (Otherwise, results would have been affected by the other metal.) The results are indicated in Table I. The tolerances are ±25 numbers in the 350-Dph range to 15 in the 200-Dph range.

The inspection department has charge of their tester, and seven qualified inspectors use it daily. These operators were thoroughly trained for at least a week before being allowed to work with the tester. The engineering department of the organization also has access to the tester so that, all in all, several hundred tests are made each week.

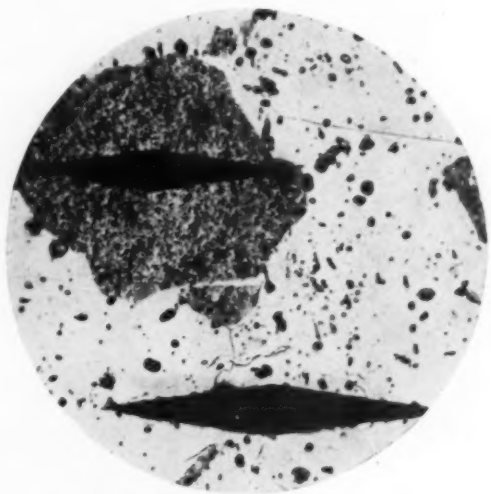


Fig. 4 – Indentations in a Lead-Antimony Alloy. The light section (particles of antimony in lead) had a hardness of Knoop 5, while the darker section (a solid solution of antimony in lead) had a hardness of 10. Magnification, 250 ×; load on indenter, 25 g.

Conclusions

Before predicting what might lie ahead in microhardness testing, it might be well to point out that the theory and application presented in these two articles applies to the metalworking industry. In addition, considerable strides have been made in testing for the mineralogy, ceramics and plastics fields. Prior

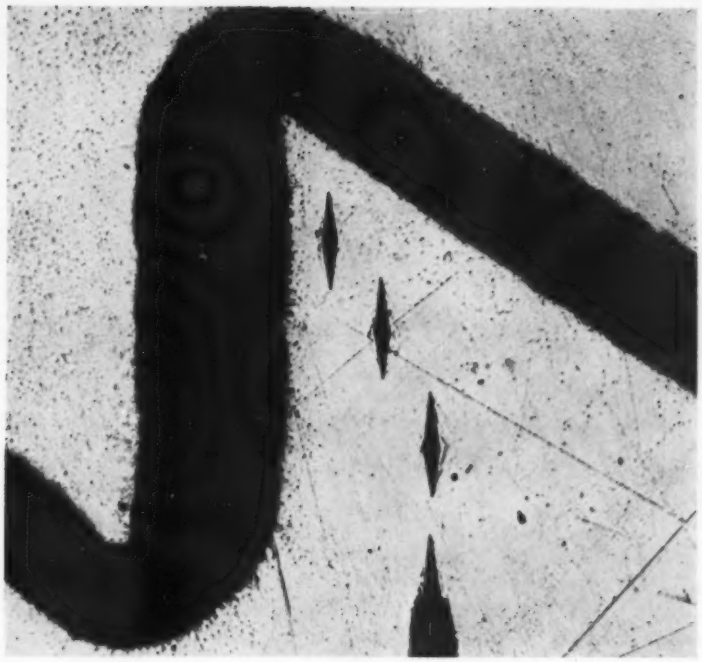


Fig. 5 – Indentations in Teeth of Hacksaw Blade. Note that indentations get smaller as cold worked edge is neared. Magnification, 40×; load on indenter, 100 g.

to the advent of this form of testing, it was very difficult, often impossible, to test these brittle and sometimes soft materials.

A general rule as to when the macro and microhardness test should be used might prove helpful. As a guide, the normal Rockwell tester, using the C scale, could be used for testing material 0.025 in. or thicker. The Rockwell superficial tester, 30 N scale, is used when the material is 0.010 in. or thicker, and the 15 N scale is used when the material is between 0.005 and 0.010 in. (As a precaution, the 15 N scale is not sensitive; small differences in hardness often cannot be easily differentiated.)

Below 0.005 in. reference should be made to the microhardness tester. On hard steel using the 1000-g. load, we can test samples of hardened material as thin as 0.005 in. Though some progress is expected in reducing applied loads below 1 g. (the lowest limit used today), far more important is the potential value of microhardness testing in production. Such applications will not, at the beginning at least, involve loads lower than 100 g. The future will see apparatus which is simple to use, and which, while not as rugged as macrohardness equipment, will be rugged enough to be used in the inspection departments of industrial plants. In such use, the load dependence will not be as important a factor as it is in the laboratory.

For such testing, direct reading methods would be very advantageous. Where tolerances would permit, this may be possible without sacrificing accuracy. Surfaces are also important. We will need a preparation technique which will produce surfaces that do not have an influence on the hardness results.

All in all, microhardness testing appears to have an assured future in industry. As its limitations are gradually overcome, the method will be used to an ever greater extent in precise inspection and testing of finished material. Though it is unlikely that microhardness testing will replace the standard Rockwell and Brinell methods, it seems certain to become an invaluable supplement to them.

Table I – Variation of Hardness Numbers With Strip Thickness

Applied Load	Total Thickness of Bimetallic Strip	Diamond Pyramid Hardness Number (Approximate)
25 g.	0.001 to 0.0029 in.	200 to 350
100	0.003 to 0.049	200 to 350
500	0.005 to 0.0095	200 to 275
1000	0.005 to 0.0095	275 to 350
2500	over 0.010	200 to 350

Short Runs

Zone Refining Ultra-Pure Silicon

SILICON, ONE OF THE TWO ELEMENTS (the other is germanium) used for transistors, is now being produced to extreme purities by floating zone refining in a vacuum. To supply this environment, a number of vacuum chambers were built for Merck & Co. (who process the metal) by F. J. Stokes Corp. These chambers maintain the ultra-high vacuum conditions continuously and uniformly throughout refining cycles which regularly last several hours.

Why refine in a vacuum? Unfortunately, silicon cannot be purified in a crucible by ordinary melting techniques, as germanium can be. Boron, in particular, possesses a distribution coefficient of nearly unity; hence it will not readily segregate from silicon. Moreover, quartz (the only well-known crucible material thus far found suitable for silicon melting) contains so much boron that it will contaminate silicon. Also, silicon absorbs oxygen from quartz crucibles, and this, too, is not desirable.

Merck's answer is floating zone refining – a crystal-growing technique which permits the material to crystallize from the liquid melt without coming in contact with a crucible. This technique is especially applicable to silicon, which possesses a high surface tension in the liquid state along with a relatively low density.

In floating zone refining, an ingot of silicon is supported vertically between two chucks. As Fig. 1 shows, a narrow zone of silicon is melted (by induction). This molten zone is moved along the length of the ingot, picking up and carrying impurities as it approaches the end of the ingot. The number of passes determines the degree of purification that is achieved.

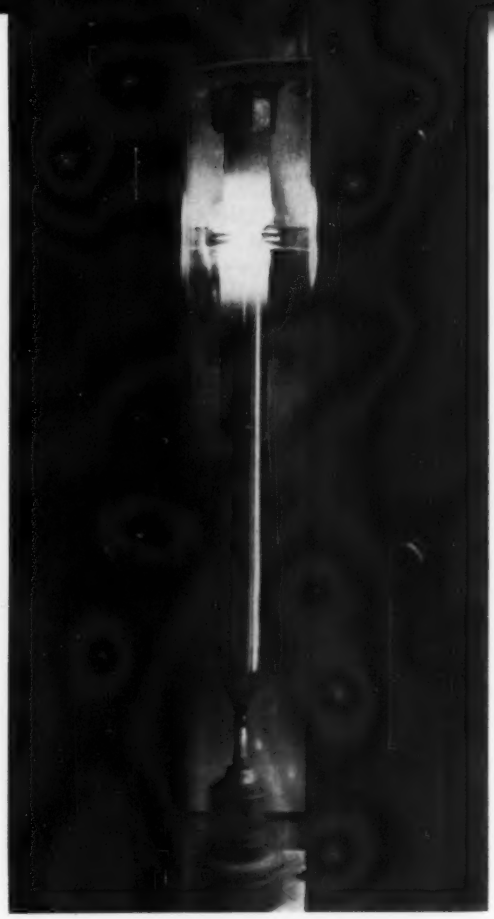
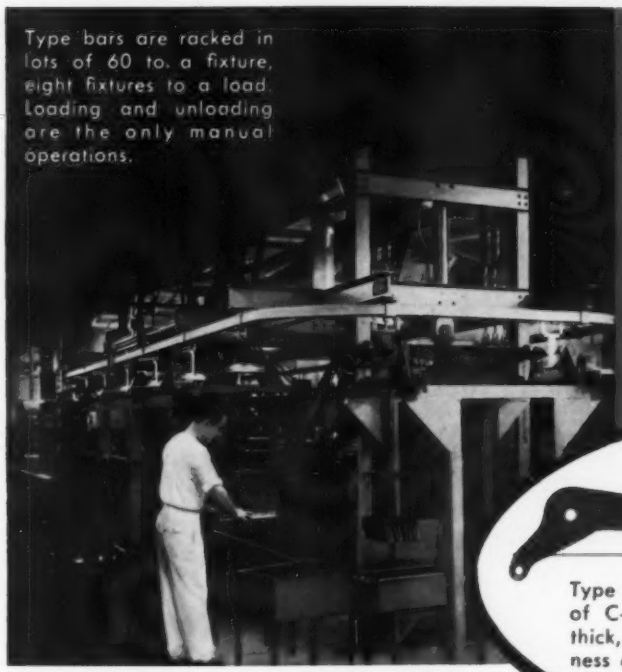


Fig. 1 – An Ingot of Silicon Being Refined in a Vacuum by the Floating Zone Method. As the ingot spins, the molten zone is moved along its length, picking up and carrying impurities as it progresses. Some of the impurities – arsenic and phosphorus, for example – volatilize in the vacuum

When the zone refining is carried out in a vacuum, many of these impurities (such as arsenic and phosphorus) can be removed from the silicon by volatilization alone.

Vacuum is also fundamentally purer than any inert gas, and a lot cheaper. For purification by evaporation, the pressure in the chamber must be reduced to a point lower than the vapor pressure of the impurities in the feed stock (the ingot of silicon as it is placed in the chamber *before* refining). Also, the high vacuum is necessary to prevent corona discharge.

As an added refinement, the induction coil is placed inside the chamber so that it closely surrounds the silicon ingot. Thus, the molten zone is further supported by the levitation force of the electromagnetic field. Because of this, large diameters of crystals are possible; Merck is now producing single crystals up to 25 mm. diameter.



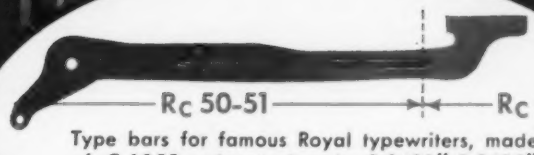
Type bars are racked in lots of 60 to a fixture, eight fixtures to a load. Loading and unloading are the only manual operations.

65% INCREASE to 14,000 type bars an hour

45% REDUCTION in rejects

ELIMINATION OF a previous straightening operation

MATERIALLY LOWER LABOR COSTS



Type bars for famous Royal typewriters, made of C-1055 strip steel only 0.0400"-0.0405" thick, are automatically heat treated for a hardness of R_c 50-51 at the fulcrum ends and only R_c 41-42 at the type ends.

Automatic Austempering Means All of this for Royal McBee

. . . and greatly improved type bar quality, too!

Typewriter type bars must be hard enough to withstand constant hammering; soft enough to take a severe bend; rigid enough to hold their complex shape and flexible enough to follow the bar guides smoothly. About 80% of their length at the fulcrum ends must be accurately hardened to R_c 50-51. Then the type ends — less than 1" of the total bar length — must be drawn to R_c 41-42.

Not a simple heat treating job — yet Royal McBee Corporation now handles it in automatic Ajax electric salt bath equipment — better and at an important cost saving. One mechanized unit combines rapid, uniform heating with austempering in "the world's most versatile quench ." This is followed by a selective draw of just the type ends and the usual cleaning operations.

14,000 bars an hour now compare with a previous capacity of only 8,500. Work comes out straight and scale-free. Rejects have been reduced by almost half. Important labor savings have been achieved and the quality of these critical parts has been substantially improved.

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Circle 1124 on Page 48-B

CORRESPONDENCE

Nickel as a Hardener of Iron

NEW YORK

In gathering data on the effects of nickel on the properties of iron, a rather interesting and (to me) convincing coordination of cause and effect evolves which does not appear to have been observed heretofore.

Figure 1 is the Honda-Miura iron-nickel transformation diagram which has been generally confirmed by other workers and is commonly accepted as most nearly correct. Figure 2, after Bain, shows how nickel affects the hardness of iron, and it apparently shows that nickel is a hardener when added to form a solid solution with iron. Does it, really?

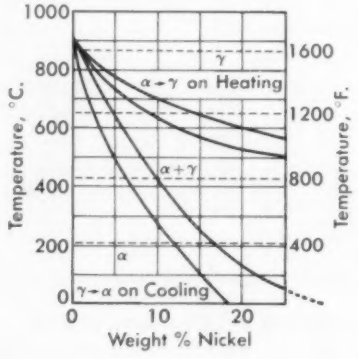
It is known that the hardness of iron is increased by rapid quenching which lowers its Ar_3 transformation. Figure 1 shows that nickel, like rapid cooling, also lowers the Ar_3 of iron. By plotting the hardness against increasing percentages of nickel, as shown in Fig. 2, against the beginning of the Ar_3 temperatures produced by corresponding nickel additions, as shown in Fig. 1, we get the straight-line relationship in Fig. 3. The Brinell 270 hardness plotted at 50° F. is the value obtained by Dehlinger and Bumm (*Zeitschrift für Metallkunde*, Vol. 26, 1934, p. 112) for 29% nickel-iron alloy fully transformed to martensite by refrigeration. This transformation, according to Fig. 1, starts at 50° F.

It thus appears that it is not nickel in solid solution, *per se*, that is responsible for the increase in hardness of iron but, rather, the low Ar_3 incident to its presence. Nickel is probably rather ineffective as a hardener in solid solution in ferrite.

In Fig. 3 data on manganese are also presented, the Ar_3 having been derived from Fig. 1, p. 465 of the Metals Handbook, 1948 edition.

By quenching pure iron specimens at various rates and determining the temperature at which the Ar_3 occurs and the corresponding Brinell hardness, a similar curve could be drawn for pure iron. Any differences be-

Fig 1 – Effect of Nickel on the γ-α(Ac₃) Transformation Temperature of Iron Upon Heating and Cooling



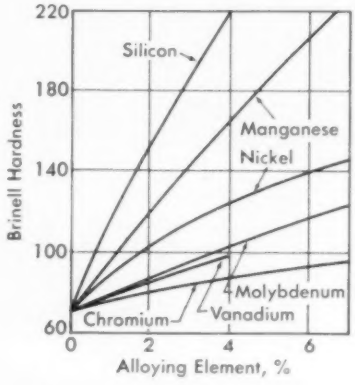
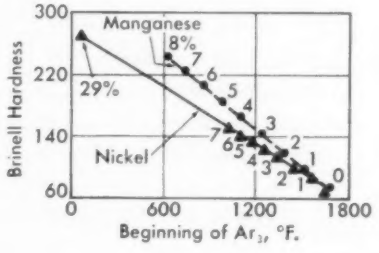
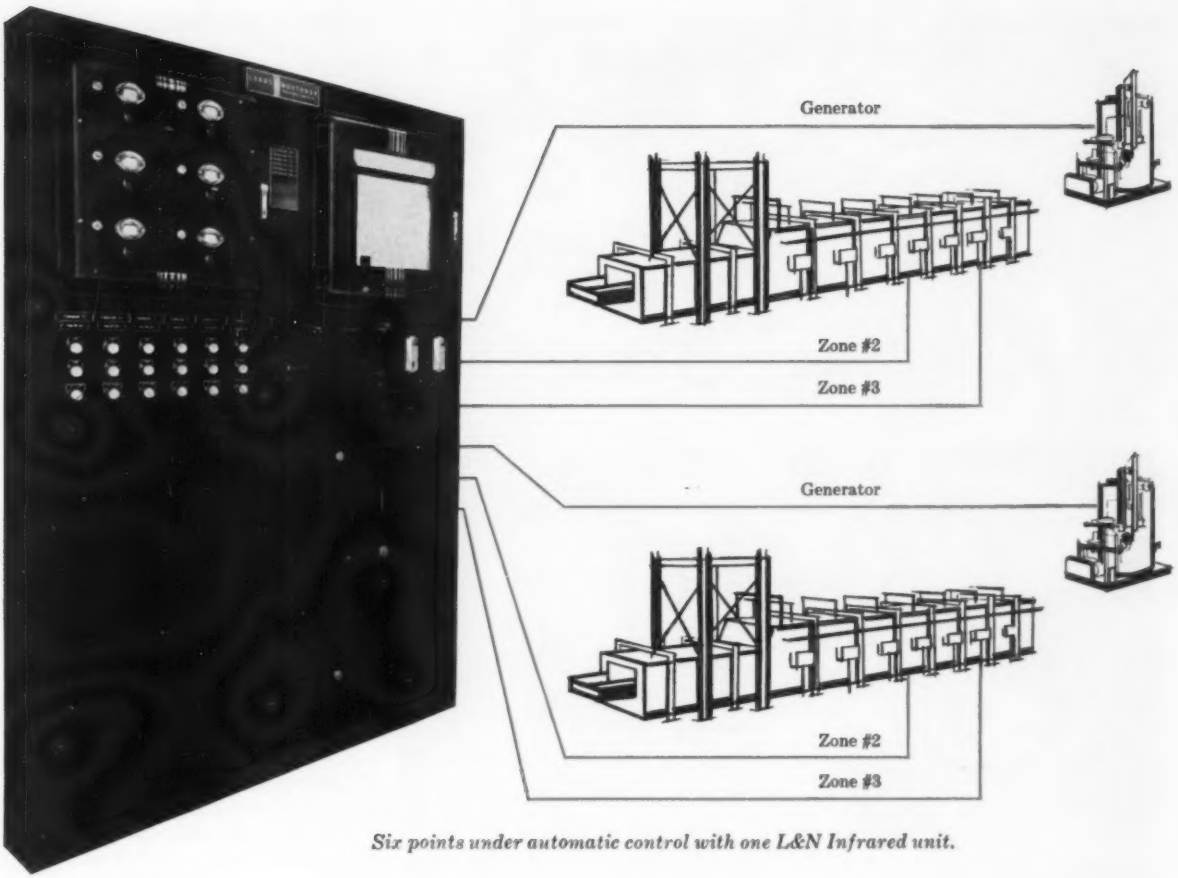


Fig 2 – Effect of Alloying Elements on Hardness of Alpha (Body-Centered Cubic) Iron. (E. C. Bain, "The Alloying Elements in Steel", A.S.M., 1939, p. 66)

Fig 3 – Effect of Lowering the Ar_3 of Iron by Additions of Nickel and of Manganese on Brinell Hardness. Numbering on point is per cent of element present





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New L&N Infrared Analyzer Package automatically holds furnace and generator atmospheres "in line"

The L&N IR Analyzer equipment for automatic control of heat treating atmospheres offers five outstanding advantages.

- *It is rugged, reliable and easy to operate.*
- *It is a completely assembled package with all necessary "hardware" panel mounted, piped and wired.*
- *Each unit may be calibrated for either CO, CO_2 or CH_4.*
- *Calibration is accurate and positive . . . requires only three minutes, on-the-spot.*
- *Generator and furnace atmospheres of as many as six points taken from any location in your heat treat can be controlled by one unit.*

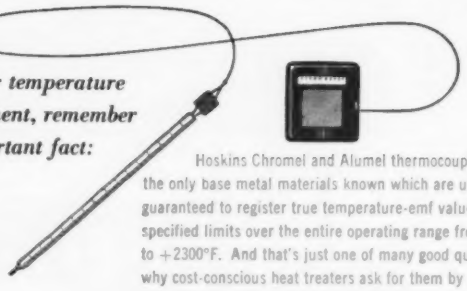
This new package of the time-proven L&N IR Analyzer, designed specifically for metallurgical use, is now automatically controlling atmospheres in a number of well known metalworking plants. It has earned the respect of management and operating personnel alike for its accuracy, dependability and ease of maintenance.

For more information request Folder N-91-620(1) from your nearest L&N office or write 4927 Stenton Ave., Phila. 44, Pa.

LEEDS Instruments LN NORTHRUP Automatic Controls • Furnaces

Circle 1125 on Page 48-B

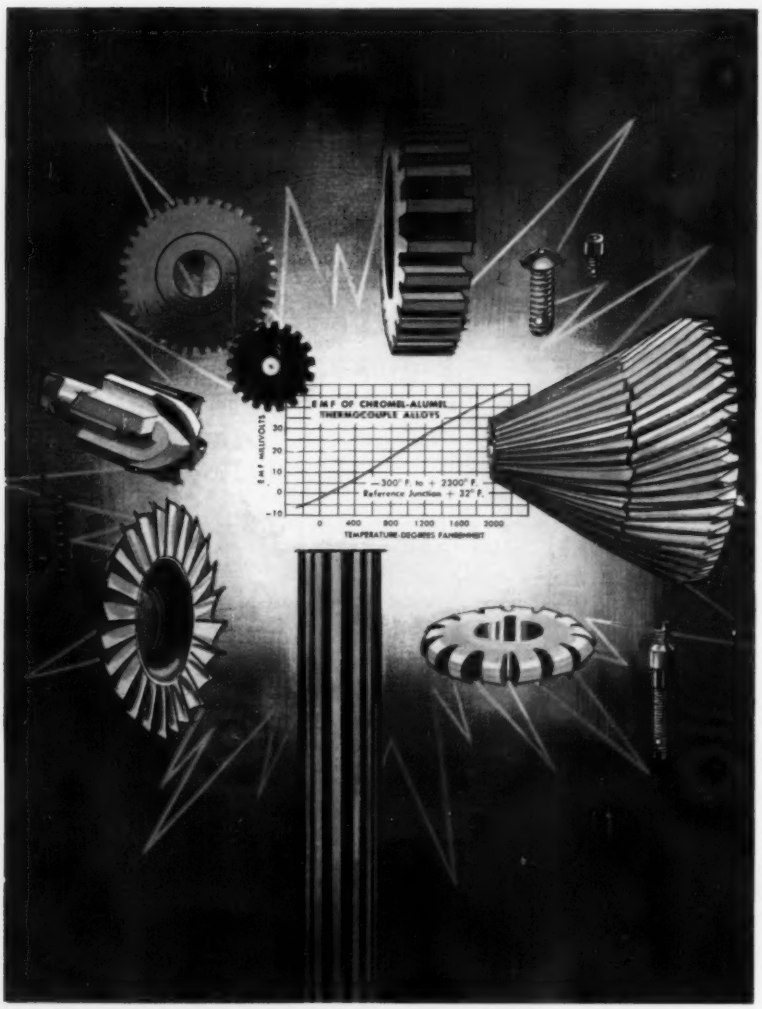
When you buy temperature control equipment, remember this very important fact:



Hoskins Chromel and Alumel thermocouple alloys are the only base metal materials known which are unconditionally guaranteed to register true temperature-emf values within close specified limits over the entire operating range from −300°F. to +2300°F. And that's just one of many good quality reasons why cost-conscious heat treaters ask for them by name . . .

Chromel®-Alumel®*

THERMOCOUPLE ALLOYS


EMF OF CHROMEL-ALUMEL THERMOCOUPLE ALLOYS
−300° F. to + 2300° F.
Reference Junction + 32° F.
EMF MILLIVOLTS
TEMPERATURE-DEGREES FAHRENHEIT

Available through instrument manufacturers, thermocouple fabricators, and pyrometer service companies. Write for complete technical data.

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Genuine Chromel and Alumel are produced exclusively by

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Custom Quality resistance, resistor and thermo-electric alloys since 1908

Circle 1126 on Page 48-B

Correspondence . . .

tween it and the two lines shown in Fig. 3 for nickel and manganese would indicate the true contribution to hardness which the alloying elements have made. However, this approach is impracticable, since Ar_3 cannot be lowered sufficiently to harden pure iron measurably.

FRANCIS B. FOLEY
(Past-President,)
Development and Research Div.
International Nickel Co.

Flame Hardening Gears

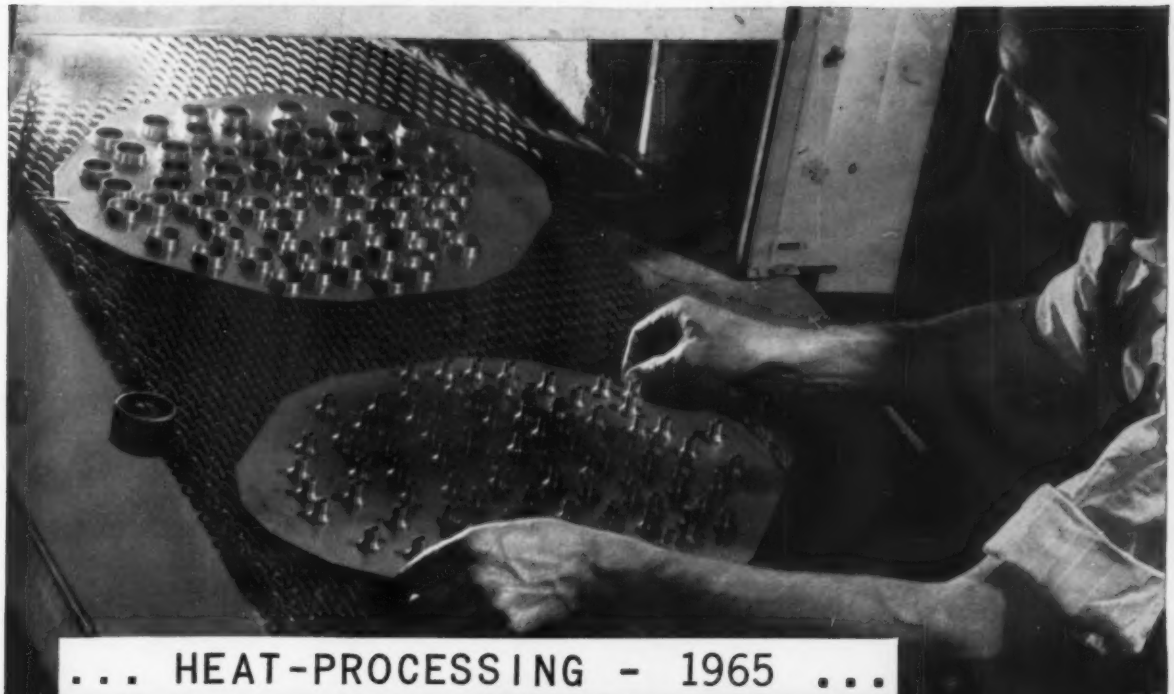
DETROIT

In the opening paragraph of "The Flame Hardening of Gears", by John T. Howat *(Metal Progress,* April 1960, p. 76), he states that flame hardening of gears was first used in England in 1919.

In England, the process antedates 1919 and I believe was in use prior to 1914. The Vickers-Sumter process of hardening by means of oxy-acetylene flames simultaneously applied on each side of a single tooth, followed by water quenching, was used for the crown bevel gears of automobile rear axles. I believe the method was patented and invented by Mr. Sumter and that the steel used was similar to A.I.S.I. 4140. I do not know how widely the process was used for automobile bevel gears, since I had no experience with this use. As an aircraft engine design and development engineer, I did, however, apply the process to the local hardening of a roller bearing crankshaft of a British aircraft engine early in 1915. I have long since lost the records of this application and indeed am not even sure that I have spelled Mr. Sumter's name correctly.

At this time, straight-tooth case hardened gears were generally used in England and die quenching of the crown wheel was not used (and may not have then been known). Warping of the gears in heat treatment resulted in major difficulties in securing silent axles. Hand stoning of the gear teeth was resorted to for the more expensive cars, and it has often been said that hand stoning the gears of a Rolls-Royce rear axle cost more than the total manufacturing cost of a Ford Model-T.

S. D. HERON



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PERSONAL MENTION

Stanley Abkowitz

The manager of refractory metals product development for the Metals Div. of Kelsey-Hayes Co. in New Hartford, N.Y., is STANLEY ABKOWITZ. A member of the research and development staff, he is concerned primarily with development of new products for ultra-high temperature service.

After graduating from Massachusetts Institute of Technology in 1948 with a B.S. degree in chemical engineering, he became a plastics engineer at Foster Grant Co., Leominster, Mass. Three years later he moved to Watertown, Mass., as materials engineer at the Watertown Arsenal. Joining Mallory-Sharon Metals Corp. in Niles, Ohio, in 1955 as staff metallurgist, he was named manager of materials and process development and directed research on a number of metals including titanium, chromium and beryllium.

He has a number of published papers to his credit on metals and metal processing, and five patents on new titanium alloys.

Irving Whitehouse

IRVING WHITEHOUSE has succeeded the late Earle C. Smith as director of research for Republic Steel Corp. in Cleveland. Mr. Whitehouse, who has been with Republic 25 years, joined the company as a sales engineer in the steel and tubes division. He was promoted to manager of the process and product development division in 1940 and two years ago became assistant director of research.

A graduate of Yale University, he also received a degree in mechanical engineering from Massachusetts Institute of Technology.

His technical affiliations include the Society of Automotive Engineers, the American Society of Mechanical Engineers, A.S.M. and the American Chemical Society.

Willard L. McCormick – from manager of manufacturing for Gianinni Plasmadyne Div., Plasmatron, Santa Ana, Calif., to Sandia Corp., Albuquerque, N. M., as consultant engineer.

John A. Ferrante, Sr. – now sales engineer at the newly opened Los Angeles sales office of Wallingford Steel Co.

Jeanne McHugh Kerr – former technical librarian of the American Iron and Steel Institute, granted a Fellowship by the Huntington Hartford Foundation for the completion of a biography of Alexander Lyman Holley. Research for the book, which also includes the background of the bessemer process, was done in Europe, particularly England, as well as the United States.

W. R. Schick – now welding engineer with Dow Chemical in Midland, Mich.

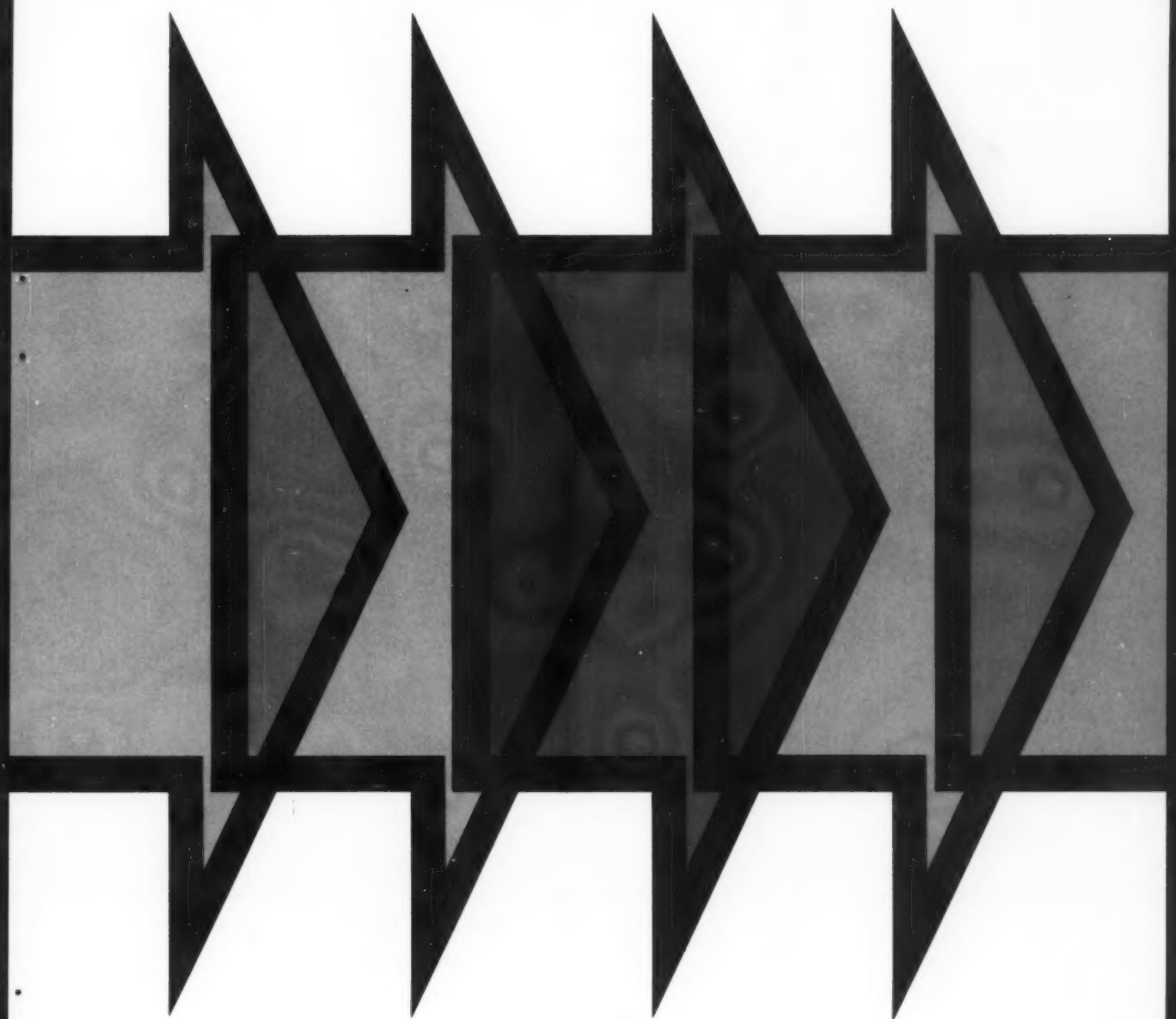
Jack I. Medoff – from research division, college of engineering, New York University, to autonetics division of North American Aviation, Downey, Calif., as senior research engineer. He was awarded his doctorate of engineering science in metallurgy in 1959 from N. Y. U.

William E. Shepherd – from oxygen steel melter at Algoma Steel Corp., Sault Ste. Marie, Ont., Canada, to openhearth practice engineer, Great Lakes Steel Corp.

B. C. Hart – now assistant metallurgist at the Advanced Technology Laboratories in Mt. View, Calif.

Gareth Thomas – currently lecturer and research metallurgist at the University of California in Berkeley, Calif.

Donald Willson – instructor in theoretical and applied mechanics at Oklahoma University, received his M.S. degree in engineering from the University.



FROM GREAT LAKES STEEL

15 X-A-R 30

ABRASION RESISTANT STEELS

TWO NEW STEELS—HARDER FOR HARDER JOBS

X-A-R

ABRASION RESISTANT STEELS

HARD ENOUGH AND TOUGH ENOUGH TO LAST

Is abrasion your constant enemy? If your equipment meets materials as they're scooped, shoved, slid, pushed, dragged or dumped, does it face the recurring threat of downtime for repairs or replacement? To eliminate such maintenance headaches, Great Lakes Steel has developed two tougher, harder alloy steels—X-A-R 15 and X-A-R 30. They're supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range of hardness between 265 and 500 Brinell). And they're especially effective and economical in those critical bear-the-brunt areas of the equipment where wear is worst—liners, teeth, bars, blades and plates, for example. *Under conditions that commonly wear out equipment in a hurry, X-A-R abrasion-resistant steels outwear any other type of steel.*

Great Lakes Steel is a division of

WHERE MATERIALS COLLIDE WITH EQUIPMENT

Chemical composition alone is not the secret of low carbon X-A-R steels; their balanced combination of uniformity, high strength, hardness and toughness is the result of close control during heat-treating, quenching and tempering. This makes them more workable, too. Under normal welding and fabricating conditions use X-A-R 30. For *extremely* difficult problems, such as welding under cold conditions or extensive flame cutting, choose X-A-R 15.

X-A-R abrasion resistant steels are immediately available in ⅛″ to 1″ thicknesses, widths up to 72″ and lengths up to 35′. For technical information and supply sources, see next page.

X-A-R

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

NATIONAL STEEL CORPORATION

15 X-A-R 30

TECHNICAL INFORMATION

CHEMICAL COMPOSITION

X-A-R steels are furnished at two specified carbon ranges. These are 14 to 20 carbon for X-A-R 15 and 25 to 30 carbon for X-A-R 30. The balance of the typical composition is:

Manganese	.80%	Chromium	.65
Phosphorous	.020	Molybdenum	.20
Sulphur	.028	Zirconium	.06
Silicon	.60		

TYPICAL MECHANICAL PROPERTIES

	At Brinell Hardnesses of: 363	400
Tensile Strength, psi	180,000	200,000
Yield Strength, psi	165,000	180,000
% Elongation in 2"*	17	16
% Reduction in Area*	56	55
Charpy V Impact at —75°F.	12 (Ft. Lbs.)	7

*Based on standard .505" specimen

ENGINEERING DATA

Resistance to Atmospheric Corrosion (Rural, Marine, and Industrial Environments)	3-5 times copper-bearing or carbon constructional steel
Compressive Yield Strength, psi	Approx. equal to Tensile Yield Strength
Ultimate Shearing Strength, psi	Approx. equal to Tensile Yield Strength
Modulus of Elasticity, psi	29/30,000,000
Endurance Limit (rotating beam)	60% of Tensile Strength
Coefficient of Expansion per °F.	70°F. to 200°F.—.0000062

FABRICATION

Cold Bend Test: Moderate bending can be performed within the usual range of hardnesses. For free bending, it is recommended that a mandrel be used not less than ten times the thickness of the metal through an angle of 90°.

Welding: Low hydrogen electrodes are recommended for welding X-A-R steels. The grade of electrode used is dependent on the strength requirement of the weldment.

Burning: X-A-R steels can be flame cut without pre-heating or stress relieving after cutting.

COMPLETE METALLURGICAL SERVICE

In addition to the information given in this folder, there is a great deal of detailed data available to steel users covering all characteristics of X-A-R steels. Furthermore, a thoroughly competent metallurgical service organization is available to work with you on any application problem you may have.

X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

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Los Angeles, California

INTERSTATE STEEL COMPANY
Evanston, Illinois

LOCKHART IRON & STEEL COMPANY
Pittsburgh, Pennsylvania

MARSH STEEL & ALUMINUM COMPANY
Kansas City, Missouri

O'NEAL STEEL, INCORPORATED
Birmingham, Alabama

SALT LAKE HARDWARE COMPANY
Salt Lake City, Utah

A. C. LESLIE & COMPANY, LIMITED
Montreal, Canada

15 X-A-R 30
ABRASION RESISTANT STEELS

AQUADAG® SOLVES AN INTRICATE MOLD PROBLEM FOR OSWEGO CASTINGS

A complete permanent mold, used in casting high-pressure gas meter housings, is shown being sprayed with 'Aquadag'.

The problem at Oswego Castings Corporation, Oswego, New York, a division of Oberdorfer Foundries, Incorporated, involved the effective metal flow and release of aluminum castings. Frequent breakage occurred due to the complexity of the part . . . a gas meter housing containing an integral rib down the center. In the mold core, the relatively tiny aperture for forming the rib, plus the rounded corners which provide the outer "bucket" appearance to the housing, demanded a release agent that would permit easy extraction and proper metal flow.

According to Frank Fox, Production Foreman in the Oswego foundry, previous to adopting the use of an Acheson dispersion, removing the aluminum casting from the rib aperture took as long as three or four hours. Even with such care, sticking caused many castings to break at the point of the rib.

There was also the problem of metal flow. Housing walls vary in thickness between ¼ inch and the ⅝ inch flange which runs around the top. Close tolerances must be maintained to insure a proper fit during final assembly. "Holidays" caused by the improper flow of metal into critical areas of the cavity, presented a constant reject problem.

Several mold washes were tried unsuccessfully before Oswego engineers turned to 'Aquadag'—a dispersion of colloidal graphite in water. In their application, Oswego dilutes the concentrated material 1 to 3 with water. Normal commercial spray equipment is used in applying an even coating on all mold surfaces . . . one coating holding up through a run of eight to ten pieces. The 356 aluminum alloy used for the housing castings, is poured at 1400°F. The mold is preheated to 700°F. and maintained at that temperature through the casting cycle.

With 'Aquadag', the savings at Oswego have been "considerable". Castings are more uniformly formed, have smoother surface finish, and part easily. Because of greatly facilitated metal flow and release, mold life is lengthened. Rejects are the exception rather than the rule.

Oswego Castings manufactures several products with highly defined parts which require molds having intricate sliding members or collapsible cores. The fact that finding the effective lubricant they needed to overcome their *most difficult* problem, resulted in the selection of an Acheson product . . . indicates it can be of equal value to you. We invite your inquiry.

Literature Describes Production Economies In Metal Casting

A detailed discussion of the various Acheson semi-colloidal and colloidal dispersions available for coating permanent molds, die cavities, and steel and cast-iron chills, is contained in Acheson Bulletin 425. It describes why Acheson colloidal graphite is so extensively used as a mold and die lubricant, as well as an extremely effective heat-resistant parting agent. The microscopically fine graphite particles are suspended in a variety of liquid carriers. When mixed with the appropriate diluent, the dispersion can be conveniently applied by spraying, brushing, dipping, or swabbing. As mold coatings they provide greater, more uniform surface coverage. Highly tenacious, these thin coatings resist the scouring action of molten metal, do not volatilize, and will not build up. Sticking in the mold is reduced to a minimum; usually eliminated completely. Less finishing is required, rejects are fewer, and die and mold life is extended.

Additional protection of casting machines, conveyor chains, and other plant equipment is also described in Bulletin 425. The heat-resistant, non-gumming characteristics of Acheson colloidal graphite are ideally suited for the high operating temperatures of most foundry machinery. Should yours be a special lubricating problem not covered in this literature, let us hear from you. Industry experience has been that in our complete product line there is an Acheson dispersion "tailor-made" for your metal casting application.

We invite you to send for your copy of Bulletin 425, "Colloidal Dispersions For Use In Metal Casting", at your earliest convenience. It should prove helpful to you in realizing greater production economies. Write direct to Dept. MP-90.

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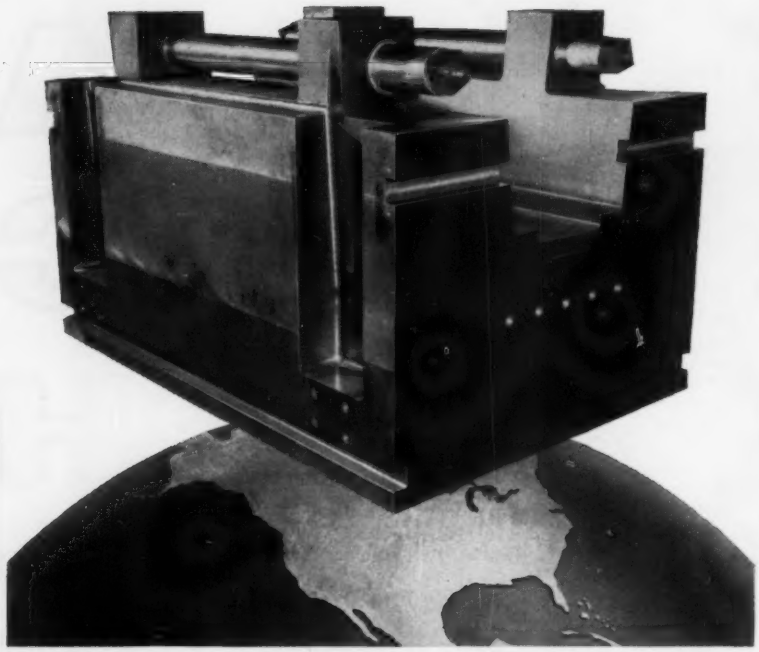
Circle 1131 on Page 48-B



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In this rarefied atmosphere, unwanted hydrogen, oxygen, non-metallic inclusions, and other impurities are literally boiled out of the molten steel, producing cleaner, tougher, stronger, more ductile, flaw-free products.

This 36,000 pound, 40" x 44" x 64" die holder is used in a heavy duty press. It was made of Finkl FX analysis, Temper 4, and finished machined in our shops.

All Finkl die blocks and hot work die steels are made from vacuum degassed electric furnace material produced in our own melt shop. Because of the clean, greatly improved qualities, you get more forging production, less downtime due to breakage, and savings in fewer tool regrinds.

You get more from Finkl in quality, continuing research, and engineering service. Call your Finkl representative for your forging, hot work die steel, and die block needs.

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Circle 1132 on Page 48-B

Personals . . .

Harold R. Beachler – from works manager of the Etna (Pa.) plant of the National Supply Co., Pittsburgh, to manager of tubular production.

Oliver B. Atkin – from chief staff metallurgist for the Bridgeport Brass Co. to plant superintendent of the Plume & Atwood Mfg. Co., Thomaston, Conn., in charge of all mill operations.

Roy S. Jamison – from technical sales engineer and sales engineering manager of the Hoeganaes Sponge Iron Corp., Riverton, N. J., to vice-president of Norwalk Powdered Metals, Inc., Norwalk, Conn., in charge of the manufacturing and engineering divisions.

J. E. Jenkins – from chief, metallurgy branch, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, to metallurgical engineer, Bristol Machine & Tool Co., Forrestville, Conn.

John P. McGowan – section chief, mold performance research, in the new research and development laboratory of Hazel-Atlas Glass Div., Continental Can Co., in Plainfield, Ill.

Merritt E. Langston – from project leader, alloy development division of Battelle Memorial Institute, to metallurgical liaison officer for the U. S. Air Force stationed in Wiesbaden, Germany.

Norbert Kopchinski – from Babcock & Wilcox Atomic Energy Div. to Atomics International, Canoga Park, Calif.

Earl D. Levine – received his Ph.D. in metallurgy from Rensselaer Polytechnic Institute, and now employed as a metallurgist at Nuclear Metals, Inc., Concord, Mass.

Glenn W. Skovson – named operations manager of Control Co. of America's newest division, known as Solid States Electronic Controls, Inc., in Tempe, Ariz.

Robert J. Bresko – from manager of quality laboratories and vendor quality, Martin Co., Orlando, Fla., to assistant quality manager, Aerojet-General, Sacramento, Calif.

new look
(and greater efficiency)
in Magnetic Particle Flaw Detection Equipment

6000 Ampere *Stationary Model*
PICKER FERROSCOPE
for Wet Technics

new outside

- *Clean-lined modern design: easy to clean, easy to keep clean.*
- *Modular principle: units combine to handle parts up to 12 feet long.*
- *Meters and signals function-grouped at eye level.*

new inside

- *New heavy duty silicon full-wave rectifiers run cooler, quieter.*
- *Heat capacity five times greater than MIL Type II specs call for.*
- *Does away with noisy, grime-blowing exhaust fans.*

3000 Ampere *Mobile Model*
PICKER FERROSCOPE
for Wet and Dry Technics

new outside

- *Roll-to-the-job unit: companion design and same finish as big Ferroscope.*
- *Easy to read meters, husky control knobs.*

new inside

- *Same heavy duty cool-running silicon rectifiers as 6000 A. unit.*
- *Heat capacity fivefold greater than required by MIL Type III specs.*
- *Either AC or half-wave DC always on tap for best results with both wet and dry technics.*
- *Stepless current control up to 3000 A.*
- *All operation controllable at machine or by*
- *remote handswitch on long cable.*

For heavy duty inspection schedules, one or the other of these Ferroscopes may be just right for you. Or maybe a smaller Ferroflux or Portaflux portable magnetic particle inspection unit would be adequate to your lighter need. In any case, call in your local Picker representative: he will be glad to advise you about these, or any of the other nondestructive inspection systems Picker offers (they're listed below).

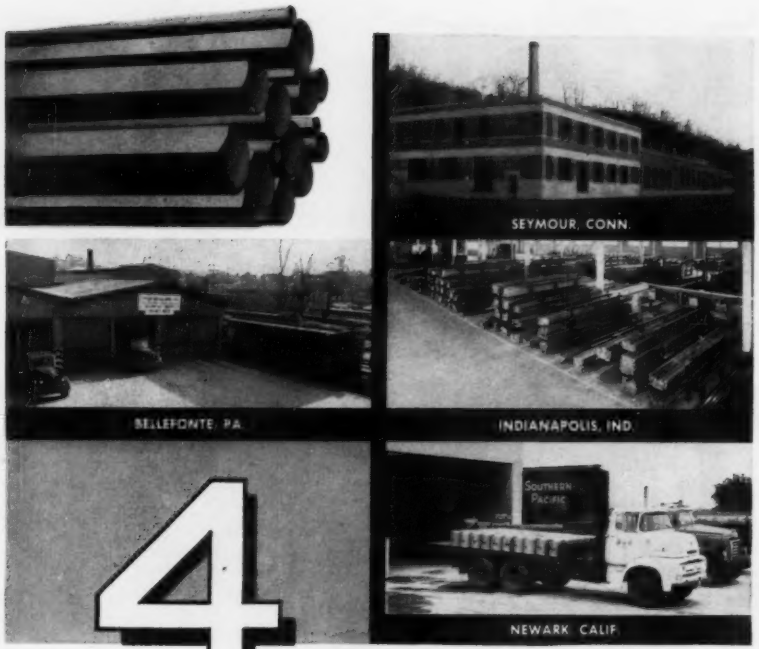
ONE STOP *for all this* ***in non-destructive inspection equipment***

Picker x-ray

PICKER X-RAY CORPORATION
25 South Broadway, White Plains, N. Y.

x-radiography	**ANDREX** portable x-ray units-140 KV, 160 KV, 200 KV, 260 KV **PICKER** x-ray units—35 KV Beryllium window, 90 KV, 110KV, 150 KV (stationary and mobile), 270 KV portable
gamma radiography	**PICKER** ***Pipeliner***—30 curies, Ir^{192}, ***Cyclops***—1500 curies; Co^{60} **TECH/OPS** Iridium^{192} units from 10 to 100 curies; Cobalt^{60} 3 to 100 curies: also Thulium^{170}, Cesium^{137}
fluoroscopy	**PICKER** Image Intensifier and associated equipment
magnetic particle	**PICKER** ***Ferroscope*** ***Ferroflux*** ***Portaflux*** **PIXmag** Ferropowders and pastes
dye penetrant	**PIXchek** Penetrants, Cleaners, Developers, and accessories

Circle 1133 on Page 48-B



4 Titan Brass Mill Depots give OVERNIGHT DELIVERY to most users!

Titan is located coast-to-coast for serving the daily requirements of warehousers, distributors, and users of brass rods. If you are within 400 miles of Titan's Northeastern, Eastern, Mid-western or Western mill depots, you can have overnight delivery on quality Titan brass.

Titan carries in stock 3,000,000 pounds of Free-Cutting Brass rounds (⅛" to 12"), hexagons (⅛" to 4½"), rectangles and squares, half-rounds, half-ovals, angles and octagons; Naval Brass, Free-Cutting Commercial Bronze, and Leaded Nickel Silver rods.

Free-Cutting Rod sizes over ⅛" to 2¼" are chamfered on both ends and are in uniform 12 ft. lengths for faster and more economical operation of automatic screw machines.

Special Titan tempers and modified free-cutting brass alloys are designed for machining in conjunction with severe knurling, deep thread rolling, deep roll stenciling, spinning, staking, flattening, bending, or flaring and expanding.

Titan depot facilities also allow quick delivery on orders of Titan brass, copper and aluminum forgings, bronze welding rods, brass wire, brass pressure die castings.

May we say more? Call Titan's nearest office, distributor or depot for outstanding brass service.

45 YEARS OF QUALITY BRASS

Write us on your letterhead if you wish to receive the weekly stock list of the Titan Brass Mill Depot in your area.

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DIVISION OF CERRO DE PASCO CORPORATION
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Circle 1134 on Page 48-B

Personals . . .

Johannes Weertman – from scientific liaison officer with the U. S. Office of Naval Research at the American Embassy in London to associate professor in the department of metallurgy and materials science at the Technological Institute of Northwestern University.

P. A. R. Findlay – from technical service engineer, Consolidated Mining & Smelting Co. of Canada Ltd., Toronto, to the associated subsidiary companies National Hardware Specialties Ltd., Dresden, Ont., and Luster Corp. of Canada Ltd., Wallaceburg, Ont., as assistant general manager.

Russell E. Duttweiler – received a degree in metallurgical engineering from the University of Illinois and is now metallurgy assistant with the International Harvester Co.

Alexander L. Feild, Jr. – from research associate for Universal-Cyclops Steel Corp., Bridgeville, Pa., to senior research engineer, astronuclear laboratory, Westinghouse Electric Corp., Pittsburgh.

S. C. Das Gupta – on leave from the department of metallurgy of Bengal Engineering College in India, working temporarily as a research associate in the Manufacturing Laboratories Inc., located in Cambridge, Mass.

John Zotos – from assistant chief of the Watertown Arsenal Rodman Laboratory's experimental foundry branch to assistant professor on Northeastern University's department of metallurgical engineering.

Henry J. Fisher – from research physical metallurgist, General Electric Co., to manager, alloy development, in the technical division, Beryllium Corp., Reading, Pa.

Bruce F. Richardson – from products manager, Metals Div., Kelsey-Hayes Co., New Hartford, N. Y., to works manager of Cannon-Muskegon Corp., with responsibility for both air melting and vacuum melting operations.

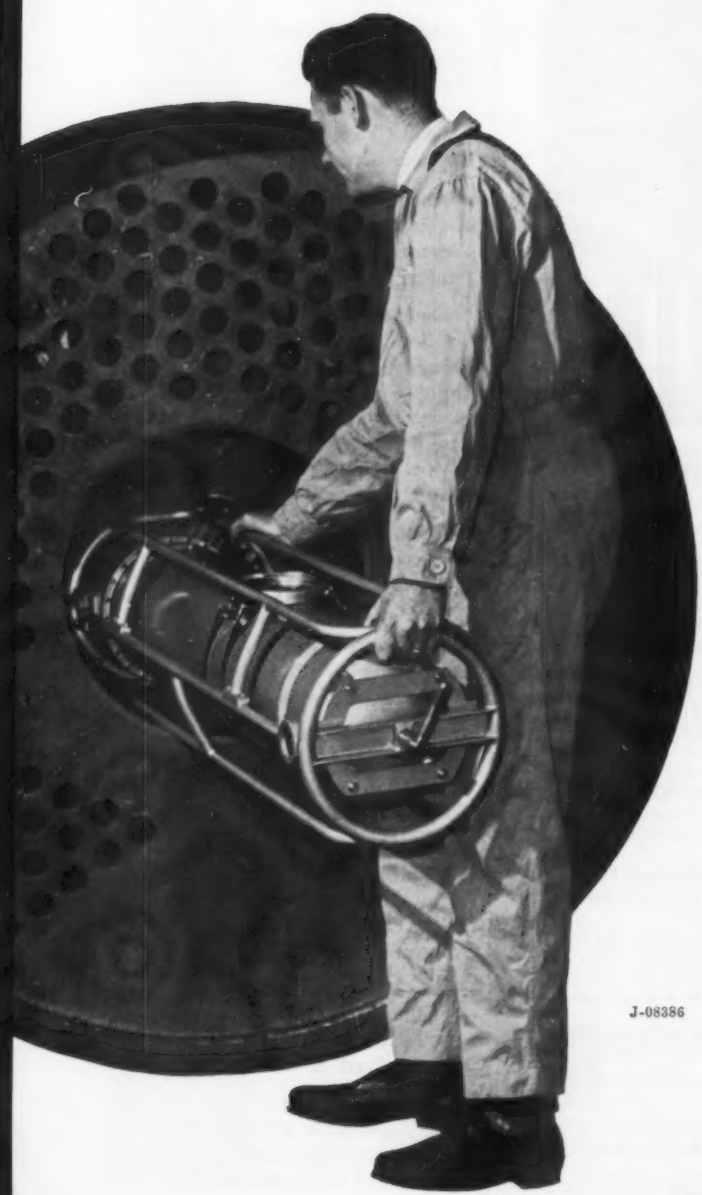
J. T. Lund – currently development engineer, Atomic Energy of Canada, Ltd., Nuclear Power Plant Div., Toronto, Ont., Canada.

NEW BALTOGRAPH 300 PENETRATES UP TO 4" OF STEEL

permits 360° radiography and can be coned down to a single beam . . . yet weighs only 136 lbs.

This is the first industrial X-ray unit designed specifically to meet *all* radiographic inspection requirements, from thin aluminum up to 4" thick steel. Simple to operate . . . requiring only a few hours instruction.

For a free demonstration—at your plant or job site—just call, wire, or write to Mr. Dan Maus, X-ray Department, Westinghouse Electric Corporation, 2519 Wilkens Avenue, Baltimore 3, Md.—*You can be sure . . . if it's Westinghouse.*



J-08386

SPECIFICATIONS

X-ray Head

X-ray tube, lead shielding, HT transformer, filament heating transformer, and automatic thermal cutoff device are all mounted in a single lightweight housing.

X-ray portal: Total X-ray beam is 30° circumferential
Focus size: 2 x 2 mm
Inherent Filtration: Low
Shielding: 5 mm of lead
Power rating: Self-rectified 300 KVP-3MA
Weight: 136 lbs.
Dimensions: 46¼ long, 12¼ diameter

Control Panel

Hermetically-sealed penetration meter, penetration selector, MA control, and automatic push button reset timer mounted in rugged metal cabinet.

Power Supply: 115 or 230 volts, 60 cycles, single phase
Weight: 41 lbs.
Dimensions: 15" x 12" x 7"
Also included: 25' and 60' connecting cables and individual carrying cases.

Westinghouse

AO Spencer Picture-in-a-minute Photomicrography

When you use the AO Spencer Photomicrographic Camera equipped with the Polaroid® Land Camera back, permanent photographs are ready for your files in just 60 seconds. A coupled visual and photographic system lets you shoot what you see . . . quickly and effortlessly. And with the Polaroid back possible errors in exposure, illumination or focus can be corrected immediately.

In addition to the Polaroid Land camera back, you have a choice of 4 other *readily interchangeable* camera backs; 4" x 5" fixed back; 4" x 5" Graflok back; 35mm back and Bantam back (roll film). You choose the camera back and film best suited to your specific requirements.

Here, the No. 682G Camera is shown being used with the new AO Metalstar Metallurgical Microscope . . . an ideal combination. The stage is focusable . . . your eye level remains constant . . . also, because the vertical illuminator remains at a fixed height throughout all focusing adjustments, you can conveniently use an external light source in place of the illuminating unit.

The sturdy vertical pillar, the easily adjustable camera support, the camera back and the Metalstar all combine to provide a compact unit. Perfect alignment and rigidity is assured . . . successful photomicrography becomes a "snap".

Try it and see for yourself. Your AO Representative will be happy to arrange a demonstration for you.

American Optical Company
SPENCER
INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Dept. J119

☐ Please send me Brochure SB682 describing the entire line of AO Spencer Photomicrographic Cameras.

☐ Please send me Brochure SB2200 describing the new Metalstar.

Name_____

Address_____

City_____ Zone____ State____

Circle 1136 on Page 48-B

Personals . . .

Quentin Augspurger — after graduation from the University of Arizona with a B.S. degree in metallurgical engineering, joined Security Engineering Div., Dresser Operations, Inc., Dallas, Tex., as a design engineer.

Jerry J. Kaufman — now studying toward a law degree.

Michael J. Ford—from research laboratory, Keystone Carbon Co., St. Marys, Pa., to research engineer, metallurgy department of the Ford Motor Co. Scientific Laboratory in Dearborn, Mich.

Donald M. Cheney — from principal technologist at Battelle Memorial Institute to associate metallurgist in metals development, Thiokol Chemical Corp., Utah Div., Brigham City, Utah.

Mason H. Baur — now commercial sales representative in the Phoenix, Ariz., sales office of Arizona Public Service Co.

Douglas C. Yearley — from welding engineer at Electric Boat Div. of General Dynamics Corp. in Groton, Conn., to metallurgical engineer working on development of new products for the Phelps Dodge Copper Products Corp.

H. H. Mays — from district manager, Province of Quebec, to sales manager in the head office, William T. Mays Ltd., Toronto.

Jack Charles Webster — to the new product research and development department of Hoskins Mfg. Co. as project engineer.

John R. MacDonald — to manager of production planning and scheduling for Phoenix Steel Corp., Phoenixville, Pa.

R. D. Randall — from Mason-Neilan Div., Worthington Corp., Norwood, Mass., to the company's Annin Co. Div., in Montebello (Los Angeles), Calif., as chief engineer.

Ira B. Gregerman — currently metallurgist at the Connecticut Aircraft Nuclear Engineering Laboratory of Pratt & Whitney Aircraft.

H. P. Yarian — organized the Titan Enamel Co. of Swanton, Ohio, and is now manufacturing marine finishes and bake enamels.

Weld failures cut 89% using vacuum-melted filler wire

Weld tests on alloy steel wire used in missile applications revealed nine times as many failures with air-melted wire as with Cannon-Muskegon vacuum-melted wire. *Superior to consumable-electrode melting, Cannon-Muskegon vacuum-induction melting greatly reduces gas levels (nitrogen less than 25 ppm, oxygen less than 25 ppm, hydrogen less than 5 ppm). Combined sulphur and phosphorus run less than .015%.*

These remarkably low gas and impurity levels can be most efficiently obtained with Cannon-Muskegon vacuum-induction melting. You are invited to write Cannon-Muskegon for further details.

☛ *Among test samples prepared from air-melted wire, 18 out of 32 failed at the weld.*

☛ *Among similar samples prepared from the vacuum-melted wire of the same grade, only two out of 32 bars failed at the weld.*

Different alloys of Cannon-Muskegon vacuum-melted welding wire are available in sizes from 1/32" to 1/8", in 36" cut lengths, or in 10 or 25-lb. spools packed in airtight Argon-filled steel containers.

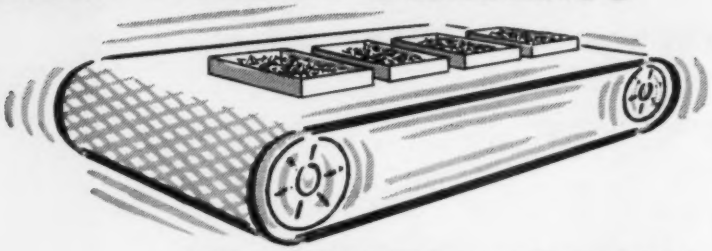
ULTRA MET

CANNON-MUSKEGON CORPORATION

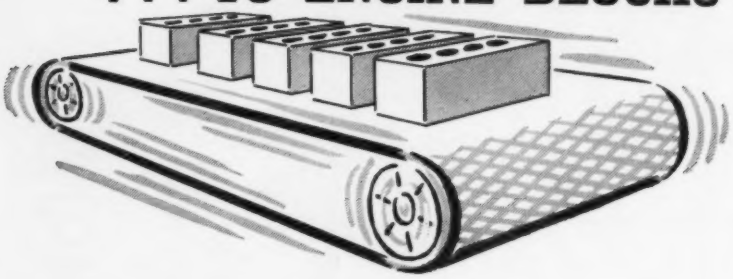
Metallurgical Specialists • 2873 Lincoln Street • Muskegon, Michigan

Circle 1137 on Page 48-B

FROM NEEDLE BEARINGS



. . . TO ENGINE BLOCKS



You can depend on

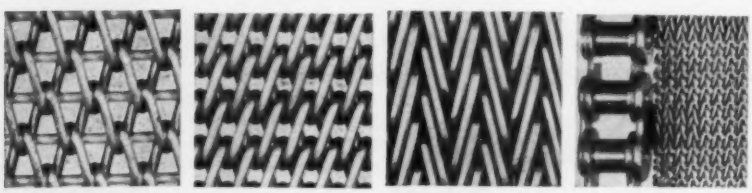
ASHWORTH METAL PROCESS BELTS

to carry the load

Any operation that depends on continuous product flow . . . brazing, hardening, quenching, annealing, tempering, washing, sintering . . . should depend on an ASHWORTH METAL PROCESS BELT to carry the load.

Process temperature and furnace atmosphere are no problem for Ashworth Engineers, they have at their command any metal or alloy that can be drawn into wire . . . they have the experience to specify the mesh or weave that will supply the correct surface characteristic to overcome any problem of circulation or drainage. Ashworth Metal Process Belts have been designed to withstand and operate at temperatures up to 2100°F.

Engineering versatility plus the finest plant facilities in the industry insure quality woven into every Ashworth Belt.



Technical literature is available with no obligation. Write for new High Temperature Catalog.

ASHWORTH BROS., INC.

WINCHESTER, VIRGINIA

Sales Offices in Principal Cities

Circle 1138 on Page 48-B

Personals . . .

Fred G. Porter – from district sales manager, Los Angeles, to district sales manager, Cleveland, for Columbia Tool Steel Co., Chicago Heights, Ill.

Nicholas E. Doyle, Jr. – from metallurgist and technical service engineer, Alloyd Corp., Cambridge, Mass., to engineer in the components section, Nortronics, Norwood, Mass.

Malcolm Basche – from project supervisor, Alloyd Corp., Cambridge, Mass., to research scientist, High-Temperature Materials, Brighton, Mass.

Michael Korchynsky – to technical supervisor, metals research group, technology department, Union Carbide Metals Co., Niagara Falls, N. Y.

Fred L. Plummer, national secretary of the American Welding Society – elected international vice-president of the International Institute of Welding at the Institute's annual assembly in Liege, Belgium.

Stuart Z. Uram – to the metallurgical staff of Hitchiner Mfg. Co., Inc., Milford, N. H., to work on investment casting developmental projects.

Rupert H. Meyers, head of the school of metallurgy, University of New South Wales, Sydney, Australia – elected president of the Australian Institute of Metals (Sydney Branch), vice-president of the Australian Institute of Nuclear Science and Engineering, and federal vice-president of the Australian Institute of Metals.

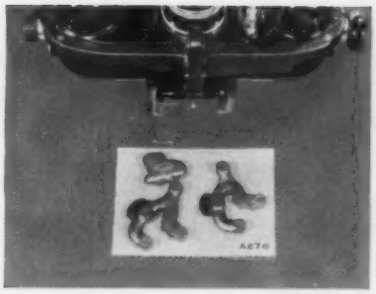
Alfred J. Brothers – to the metallurgical unit of the materials and processes laboratory of General Electric Co.'s large steam turbine generator department, working on fatigue and fracture studies.

Charles E. Weaver – from the University of Tennessee to the staff of the Oak Ridge Gaseous Diffusion Plant.

Thomas J. Behan – from assistant manager to manager of the Crucible Steel Co. of America's sales branch in Buffalo, N. Y.

Ralph E. Anderson – chief metallurgist, Brillion Iron Works, Inc., Brillion, Wis.

1) No darkroom loading. Ready for exposure as it comes from the box.



2) Just place in position and expose —the film is protected from dust, dirt, light and moisture.

3) In the darkroom, pull the rip strip, remove film, and process.

...NEW!... READY PACK ....

Kodak Industrial X-ray Film

- Sealed tight until processed—keeps clean
- Very convenient to handle—saves time
- Readily available in Type AA and Type M

Here's new convenience when you are inspecting aluminum or magnesium alloys, thin steels, plastic or anything where lead screens are not required.

Kodak Industrial X-ray Film, Type AA and Type M-Ready Pack comes to you with each sheet sealed in a light-tight envelope ready for exposure. A convenient rip strip makes it easy to open in the darkroom.

These films come 75 to a box in sizes 8 x 10, 10 x 12, 11 x 14, 14 x 17. Order them from your Kodak X-ray dealer.

Kodak
TRADE MARK

EASTMAN KODAK COMPANY
X-ray Division • Rochester 4, N. Y.

Circle 1139 on Page 48-B

Metals Engineering Digest

. . . Interpretative Reports of World-Wide Developments

Materials for Missiles and Space Vehicles

A report of a materials symposium held by the Martin Co. in Denver, May 1960.

OVER 200 ENGINEERS discussed problems relating to materials intended for use in aero and space vehicles at a materials symposium held in Denver in May 1960. Though both metals and nonmetallic materials received about the same amount of attention, most of the discussions were of interest to the metals engineer.

One of the first talks, by Howard Peckham of Martin-Denver, concerned "Contamination of Missile Fluid Systems". To assure minimum contamination potential, he recommended that designers avoid pockets, crevices, labyrinth areas, minimize screw-type fasteners or other particle-generating connectors or devices, select construction materials resistant to corrosion or abrasion, provide low rms. finish on components, use compatible lubricants only when necessary, allow for drains at low points of system, avoid contact of gaskets or seals with bulk of fluid, and use filter systems and sampling points as necessary. Comparable concern should be concentrated on individual components, and the designer should specify the level of cleanliness required in a particular system or portion of a system. Finally, control points must be rigidly adherred to at every stage of manufacturing and testing.

Temperatures Are Important

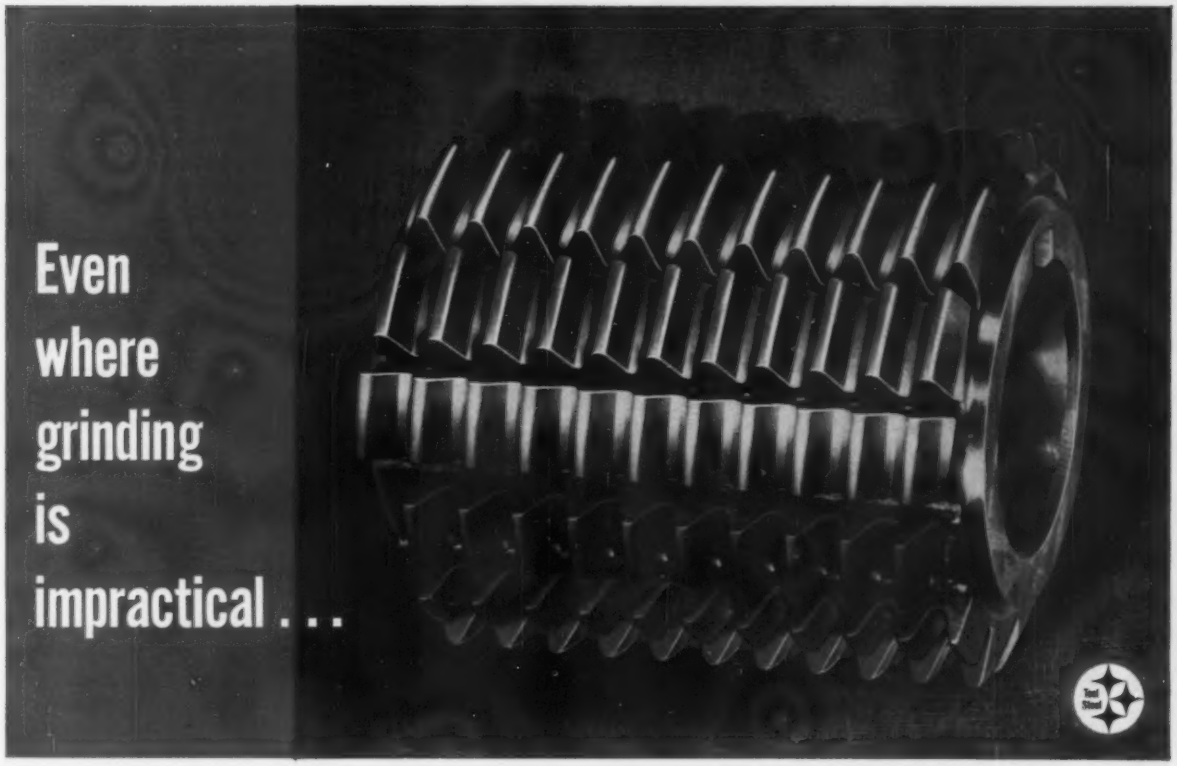
As is well known, both aero and space vehicles are expected to operate properly throughout great ranges of temperature. James Watson of Convair-Astronautics began one meeting by describing the properties and characteristics of metals at temperatures down to the boiling point of liquid hydrogen (−423° F).

Emphasizing the importance of notch toughness rather than uniaxial elongation as an acceptance criteria for metals, he outlined a great amount of notch-unnotched tensile data. Types 301 and 310 (austenitic stainless steels) show excellent notch toughness and possess high strengths at the temperature of liquid hydrogen. Of the titanium alloys, the 5 Al, 2.5 Sn alloy exhibits the best balance of properties and notch toughness. The 6 Al, 4 V alloy is not recommended for structural use below −320° F.

The general excellence of the face-centered cubic and hexagonal-close-packed crystal structures were also discussed as was the relations of microstructures to properties. He concluded by describing effects of strengthening mechanisms of high-strength alloys, and the relations of fabrication variables (such as welding, stresses, notches, and the like) to low-temperature performance.

The next speaker, K. R. Agricola (Martin-Denver), discussed the many problems faced by the designer and materials engineers who work with missiles and space vehicles. At low temperatures (−423° F.) notch sensitivity and brittleness of metals must be considered. From room temperature to 1200° F., the design is dictated by tensile, compression, buckling, shear and bearing properties. Above this temperature, creep and stress-rupture become more important. The compatibility of organic and metallic materials with liquid fluorine, liquid oxygen and storable propellants was described in some detail. Most organics detonate under impact when in the presence of liquid oxygen as do certain metals such as titanium. Metals are relatively unaffected by fluorine, N_2O_4, or hydrazine while organics behave in various manners.

Following this, Saul Bramer (Hughes Tool Co.) talked about the fabrication and application of metals for use above 2000° F. Metals of interest in this temperature range include molybdenum, columbium, tantalum and tungsten. In discussing machining, forming and assembly methods, he stated that columbium and tantalum can generally be



Dependable DESEGATIZED® XL® High Speed Steels

. . . pacesetters for machinability since 1953

For over 7 years, toolmakers have recognized the superior machinability of Latrobe's Desegatized XL high speed steels. They note a great reduction in surface finishing problems involving hobs, cutting tools and other components. Even where finish grinding is impractical, XL steels consistently meet requirements because . . .

XL high speed steels are made by the Desegatized process of manufacture—a process involving unusual melting techniques employed by Latrobe since 1946. This process guarantees full structural uniformity of the steel—no harmful carbide segregations . . . freedom from porosity . . . and an even dispersion of the *proper* amount of alloy sulphides that promote better machinability. As a result, tools made of XL steels not only possess better machined surfaces—they are consistently tougher, respond predictably to heat treatment and wear longer.

Latrobe regularly produces over 18 grades of Desegatized XL high speed steels, many stocked for prompt delivery from warehouse and mill stocks. For your next tool steel application . . . call Latrobe! Our sales engineers will be pleased to provide technical assistance to help you select the *right* steel for your application.

Manufactured by skilled American labor. . . .

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Metalmasters

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BRANCH OFFICES and STEEL SERVICE CENTERS: BOSTON • BUFFALO • CHICAGO CLEVELAND • DAYTON • DETROIT • HARTFORD • LOS ANGELES • MIAMI • MILWAUKEE NEW YORK • PHILADELPHIA • PITTSBURGH • SAN LEANDRO • TOLEDO

Circle 1140 on Page 48-E

AUTOMATE your melt analyses with a

BA DIRECT-READING SPECTROMETER

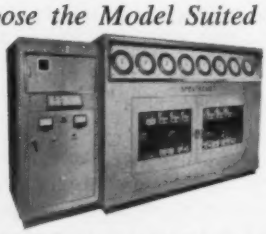
Chemical Composition In Minutes

Baird-Atomic Spectrometers — either the SPECTROMET® or DIRECT READER — allow high precision analysis of alloying and minor elements to be made quickly and easily. Results are reported to the melt shop in minutes permitting corrections to be made prior to pouring. Both units are specially designed for rugged, practical use . . . to be operated by semi- or non-technical personnel.

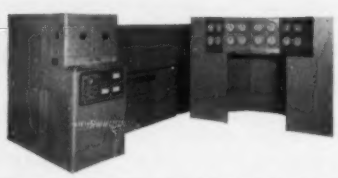
SAVE TIME, ELIMINATE WASTE, HIT SPECS ON THE NOSE

- Eliminate "off analysis" heats.
- Shorten furnace holding time — net more heats per month, minimum loss of alloy elements, longer furnace life, lower fuel costs.
- Conserve expensive alloying elements by confidently aiming at low side of the specification. Detect harmful tramp elements.
- Reduce expenses by saving manpower, supplies, and space.

Choose the Model Suited to Your Needs



SPECTROMET—rugged model designed for installation close to the melt shop without need for special laboratory.



DIRECT READER—Custom-built laboratory unit analyzes for up to 60 elements or more — dial or strip chart readout.

BOTH UNITS HAVE THESE EXCLUSIVE BA ADVANTAGES

- Automatic Optical Servo Monitor — maintains optical alignment regardless of temperature, atmospheric pressure or shock and vibration.
- Simultaneous Results with Parallel Interchangeable Channels — essentially a separate direct reader for each element. Increases reliability, facilitates maintenance. If one channel fails, other channels not affected. Channels interchangeable without recalibration.
- Wide concentration range on single scale — exclusive logarithmic presentation of results covers wide concentration range on one scale without sacrifice in precision (e.g. from .1% to 40% chromium in steel).
- High Resolution and Dispersion with 3-Meter Grating — high dispersion of grating in combination with Automatic Optical Servo Monitor aids performance. For example: phosphorus in steel in presence of copper, boron in steel, silicon in steel in presence of high chromium.
- Custom Built Excitation Source — the source best suited to each problem is custom built into the instrument.

Write for Introductory Bulletin SC-1.

BA **BAIRD-ATOMIC, INC.**

33 university road · cambridge 38, mass.

Circle 1141 on Page 48-B

Missile Materials . . .

formed quite drastically at room temperature without much difficulty. With tungsten and molybdenum, the best results are achieved by forming at 800 to 1000° F. Most important, refractory metals must be carefully handled at all times.

Ultra-high temperatures were also of interest, since they enter the picture when re-entry problems are of concern. According to Elmer Warnken (Cincinnati Testing Laboratories), who discussed relationship of fabrication to performance, the plastic lay-up usually determines the performance and physical properties of the re-entry body. He described four techniques: shingled lay-up, parallel grain, end grain, and random fiber (using chopped glass or a similar filler).

Next, Norman Wahl (Cornell Aeronautical Laboratory) discussed "Ultraviolet Effects on Materials". He began by stating that polyester glass-reinforced laminates increase in compressive and flexural strength for periods up to 500 hr. with less than 1% loss in weight when exposed up to 300° F. at pressures to 10^{-7} mm. Hg in ultraviolet wave lengths of radiation. Epoxy and phenolic glass-reinforced laminates lost about 1% in weight and 10% or more in flexual and compressive strengths at exposures up to 200 hr. Exposure of the three types of laminates above to intense radiation causes a considerable degradation in strength and loss in weight after only 3 hr. Ultraviolet waves cause the greatest degradation in strength of glass-reinforced laminates.

Another important talk (by Kenneth Mills of Martin-Denver) was about "Moisture Protection of Booster Electrical Systems". According to him, the selection of proper wire and cable for system is important. Teflon-insulated wire and cable is used extensively in the Titan electrical system. Best construction: silver-coated copper conductor with a primary of extruded or wrapped and fused Teflon, abrasion barrier of Teflon-impregnated glass tape or ceramic-filled Teflon tape followed by Teflon-impregnated glass braid. Because of bulkiness of properly moistureproofed hard-faced connectors, only soft-faced connectors (Type E) are used in most instances. A

AIR-CUSHIONED

vibration

Finishes parts up to 100 times faster!

New Pangborn Air-Cushioned Vibratory Finishing Machine—culmination of Pangborn's years of experimentation and refinements*—gives tremendous savings in finishing costs!

This is the 6 cu. ft. capacity Pangborn Air-Cushioned Vibratory Finishing Machine . . . perfect solution for cleaning, descaling, deburring, grinding, radiusing, fine-finishing, coloring or burnishing all metal and metal alloy parts, many suitable plastic and ceramic items.

- Works up to 100 times faster than conventional methods at lower cost.
- Most compact vibratory machine on the market.
- Air cushion suspension gives automatic leveling and amplitude control, supplants spring suspension systems subject to fatigue.
- Does work impossible to do by barrel finishing or other means.
- Standard basic machines are equipped with mechanically variable speeds.
- Floor vibration entirely eliminated, making possible (for the first time) second floor mounting.

Available in a wide range of sizes. Also auxiliary equipment, media and compounds for every need. Send parts with exact finish specifications, or finished specimen, for sample processing in our laboratory, to: Mr. William E. Brandt, PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md.

*Pat. No. 2,422,786; June 24, 1947

Pangborn
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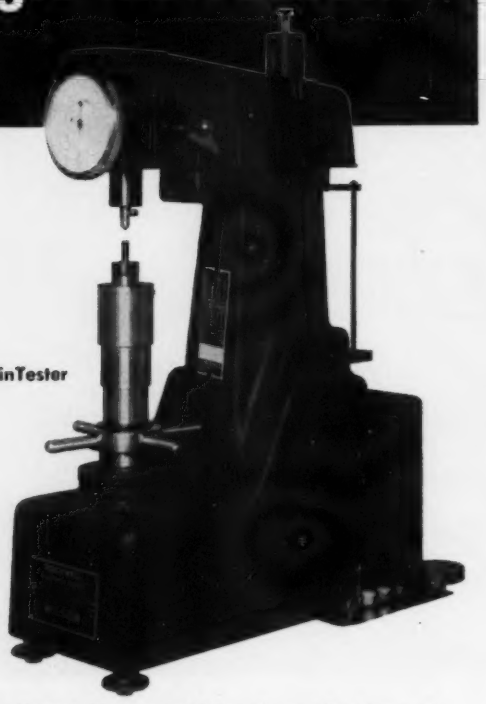
Circle 1142 on Page 48-B

Two Hardness Testers in a Single Instrument



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WILSON "ROCKWELL" HARDNESS TESTERS

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
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Circle 1145 on Page 48-B

Missile Materials . . .

rigid mica-filled epoxy used to pot connectors, and a C-269 adhesive and RTV tapes and paste are applied over the epoxy. In conclusion, the best protection for terminal connections involves a coating which is transparent, has good bond strength, good electrical properties and can be easily repaired.

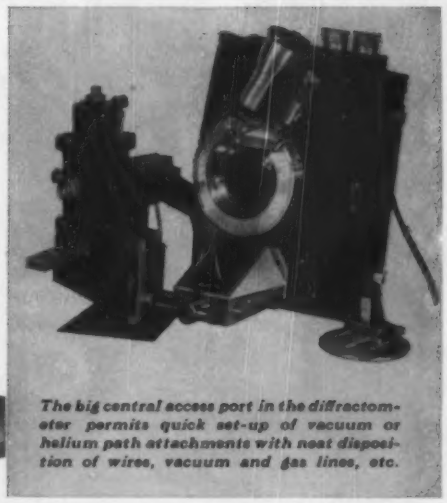
Three excellent talks by Burns, Zeilberger and MacMillan summarized problem areas in the use of materials in solid, liquid and nuclear power plants. The first speaker, H. Burns (Thiokol Chemical Co.) presented a very interesting discussion on the use of electron beam welding, and on the heat treatment of ultra-high-strength steels for rocket motor cases. When compared to TIG or MIG methods, the electron beam process yields much finer grain size and better over-all weld efficiencies. Components with diameters as large as 80 in. can be fabricated by the electron beam welding technique (although no parts that large have been fabricated to date).

Another technique of fabrication described involves the cold reduction of martensitic structures for preferential orientation of the crystals. Induced strengths as high as 335,000 psi., accompanied by yield strengths on the order of 320,000 psi., have been achieved on a 4340 alloy steel composition.

Next, E. Zeilberger of Rocketdyne discussed many of the problems encountered in rocket motors which use liquid fuel. The most critical components in such engines are seals (static, dynamic, shaft, rotary and so forth). These seals are necessary to prevent combination of propellants or leakage causing violent reactions. Reinforcing bands of epoxy fiberglas have replaced steel bands in several engine applications. Filament-wound propellant tanks, pressure vessels, and other items are being used or are contemplated for use in liquid booster systems. The speaker also described the use of fiberglas body armor between clustered engines (to prevent shrapnel damage), and the use of high-temperature resin-impregnated fiberglas and ceramic-coated plastics for thermal protection.

On the last day of the meeting, Donald MacMillan (Los Alamos Sci-

we're talking here to analytical chemists, crystallographers and metallurgists who know their way around x-ray diffraction and x-ray fluorescence analysis equipment. To people like you the importance of the advances cited below will be abundantly clear. To others of lesser technical background, any local Picker representative will be glad to explain their significance in terms of greater analytic versatility, easier operation, more accurate results.



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rotate sample independently about diffractometer axis for special precision-procedures . Makes for jiffy alignment of specimen or analyzer crystal, or detection of preferred orientation

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dozens more . . . but, alas, we have to stop somewhere. Get the *full* story on this remarkable new equipment from your local Picker representative (see 'phone book) or write Picker X-Ray Corporation, 25 South Broadway, White Plains, New York.

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Circle 1144 on Page 48-B

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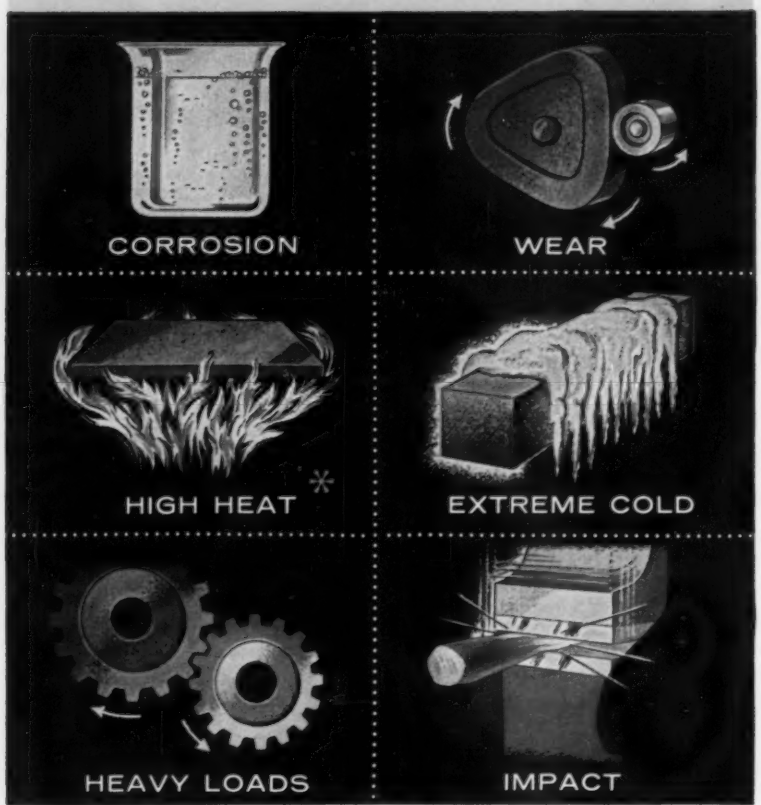

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Circle 1143 on Page 48-B

Missile Materials . . .

entific Laboratories) presented a very enlightening paper on the materials problems associated with nuclear power plants. Basically, the nuclear engine is a solid-to-gas heat exchanger. Therefore, the efficiency of the engine depends largely on the maintenance of as high an operating temperature as possible along with minimum thermal gradients. In addition to thermal problems, the designer must allow for material degradation due to fission products from the reactor core. Selection of materials for the core or heart of the reactor thus involves metals with high melting point or ceramics which couple strength with low neutron capture cross sections (except, or course, for control materials or the fissionable materials). Dr. MacMillan described test data on many materials, but was primarily concerned with graphite at very high temperatures and vigorous environment.

K. R. AGRICOLA

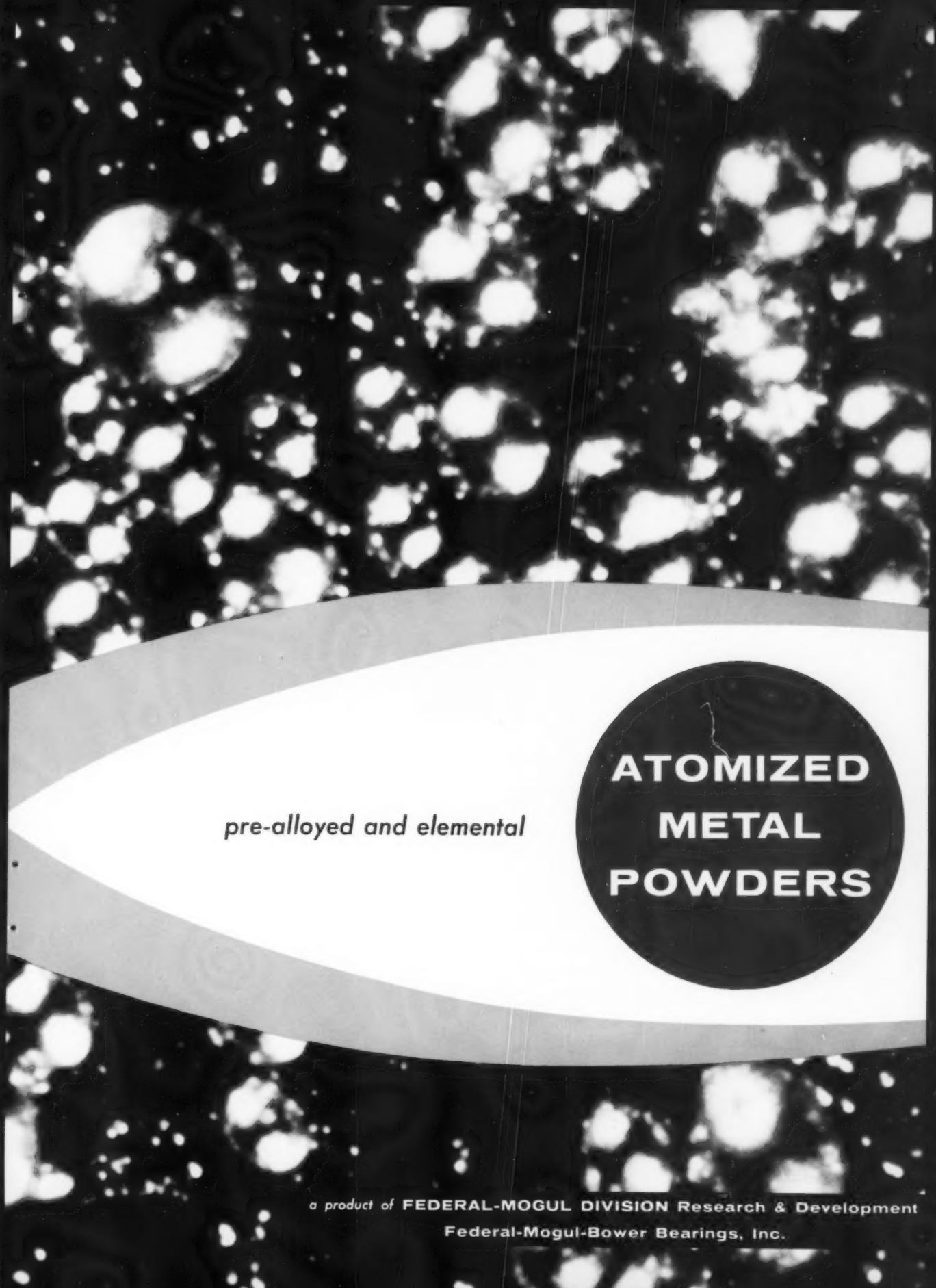
Efficient Spheroidization

Digest of "On the Spheroidization of the Carbide Phase in Steel", by D. S. Kazarnovskiy, *Fizika Metallov*, Vol. 7, p. 703 (in Russian).

THE AUTHOR studied the influence of soaking times at 1300° F. (700° C.) and cooling rates. The samples were from a medium-carbon Cr-Ni-Mo steel with A_C of 1375° F. (745° C.) with carbide existing as platelets in lamellar pearlite. Results of the heat treatment were judged by micrography.

After soaking at 1300° F. for any time up to 30 hr. and furnace cooling at 230° F. per hr., the pearlite remains lamellar. Indeed it seems that the cooling rate between 1300 and 1100° F. has the decisive influence. Thus, if this range is traversed quickly (in 45 min.), the pearlite remains lamellar after any soaking time, 5 hr. or more. After soaking time of 10 hr., the critical cooling velocity between 1300 and 1100° F. is about 55° F. per hr.; at this rate the carbide platelets began to be broken up. On further decreasing the cooling rate to 35 to 18° F. per hr. (in the range from 1300 to 1100° F.), the particles approach globular shape.

E.E.T.



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FEDERAL-MOGUL METAL POWDER RESEARCH PAYS OFF

Industry and the science of powder metallurgy now have some important new tools to work with. These new tools, in the form of fine pure metal or alloy powders, are the result of twenty years of intensive research into metal atomization methods.

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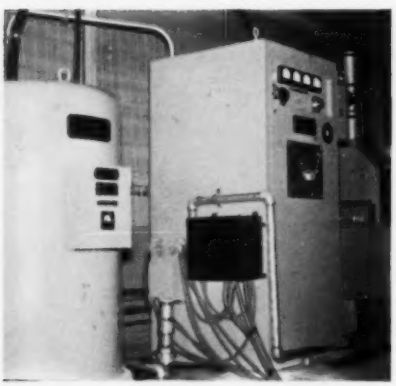
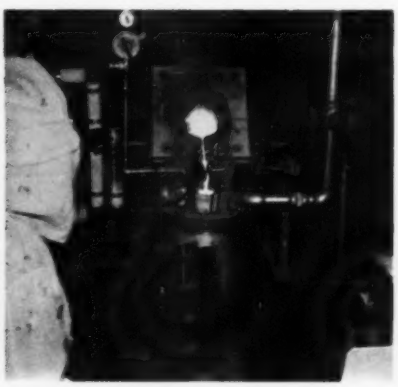
Today, pre-alloyed and elemental metal powders developed by Federal-Mogul are finding wide use in a variety of industrial and experimental applications. A continuing vigorous research program is your assurance that Federal-Mogul will assist you in meeting the powdered metal demands of tomorrow.

CONTROLLED ATOMIZATION ASSURES PRECISE POWDER QUALITY



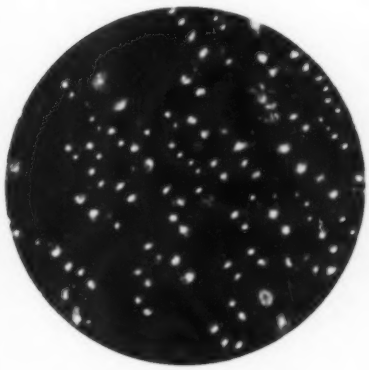
Modern, motor-generator induction melting equipment is used to melt metals quickly and efficiently.



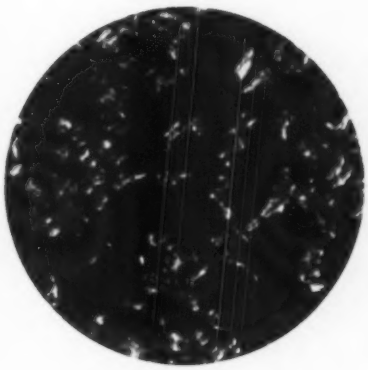
The controlled melt is atomized by a unique process efficiently utilizing various atomization mediums to produce metal powders of varying composition.

The atomized powder is collected, dried and classified.

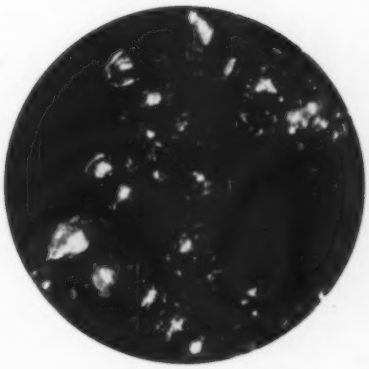
SOME METAL POWDERS PRODUCED BY ATOMIZATION



316 Stainless Steel (Spherical)



316 Stainless Steel (Irregular)



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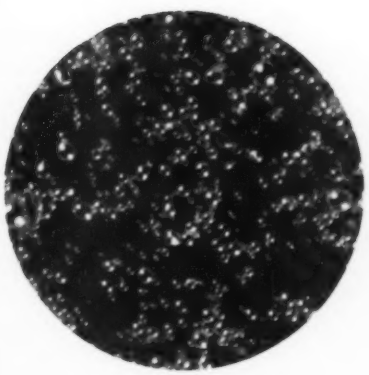
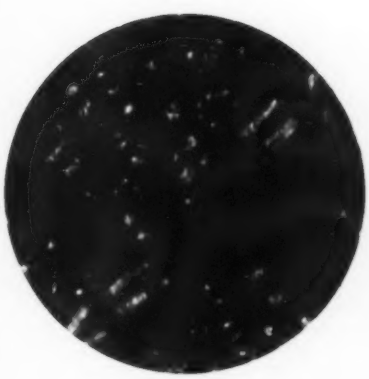


Pure Silver

Pure Copper

Aluminum-Copper-Nickel Alloy



S-816 Cobalt Alloy

Cobalt-Chromium Alloy

The physical properties of these powders, such as screen analysis or particle size distribution, flow rates, and apparent densities will vary, of course, with chemical composition and particle shape.

Actual color photographs taken in the Federal-Mogul Research Laboratory.

METAL POWDERS ARE FINDING MORE AND MORE USES

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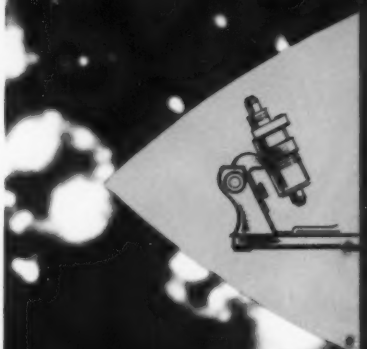
- high temperature brazing
- low temperature soldering
- corrosion resistant filters
- jet engine and rocket components
- oxide dispersion hardening
- slip casting for complex and intricate shapes
- porous media for sweat-cooling applications
- fuel cell components
- semi-conductor investigations
- new fabrication techniques for reactor fuel components

Federal-Mogul will be glad to show you how metal powders can best answer your specific needs. For more information on metal powders of any composition for these or other applications, write to Federal-Mogul Division, Research & Development, P. O. Box 1048, Ann Arbor, Michigan.



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SEPTEMBER 27-28-29-30, 1960 • CLEVELAND PUBLIC AUDITORIUM

Circle 1175 on Page 48-B

Die Casting Quality Control

Digest of "The Control of Quality of Pressure Die Castings", by H. J. Sharp, Monograph and Report Series, Institute of Metals, No. 22, 1957.

QUALITY IS EXPLORED in terms of minimum over-all tolerances in dimensions and maximum mechanical properties, with some consideration of efficiency in production. A most detailed investigation is made of all the parameters which control quality. The work is limited to pressure die castings, but it may be read with profit by all who produce any form of castings.

For the die caster, controls must be very precise, because of the rapid chilling of the metal in the die mold. If the metal entering is relatively cold, it will solidify too soon and cause a "cold shut". If too hot, cracks will form due to shrinkage and lack of feeding at thin sections. A principle which runs through the recommendations is that at no time must a large quantity of *liquid* metal be in the die mold.

Pressure die casting is defined as the forcing of liquid metal at *extremely high* pressures into a water cooled metal die cavity. The recommended practices are explored.

Machines

"Hot chamber machines" which supply liquid metal from a heated reservoir into the chamber at low pressures of 500 psi. are mentioned but not discussed. The paper is concerned with "cold chamber machines" in which the metal is melted in a separate furnace and ladled into an injection sleeve of the machine, from which it is forced by a piston into the die cavity. The difference introduces two factors which affect quality control. The second machine is not automatic, since the transfer of the liquid is by hand ladle. Also, both metal and mold are colder and the high pressure perhaps extrudes the metal through the gate into the die. The trend is to increase the pressure especially for metals like magnesium which have a low heat content. A vertical rather than a horizontal injection sleeve is recommended.

Defect Types and Inspection

Defects common to all castings will occur. A special surface blemish is due to excessive lubricant. Most defects can be seen on the surface, and if X-ray inspection accompanies early development, only occasional checks should be needed in production. The weight of the casting is a very satisfactory check on soundness. Visual and dimensional checks should be made with such frequency that production can be stopped immediately. This positive approach to inspection is recommended rather than the negative method of just preventing defective castings leaving the foundry. In some instances, a squirrel cage rotor for induction motors is mentioned, each casting being tested electrically immediately after fettling.

Types of Alloys

The author suggests that, under the conditions of use for most aluminum pressure die castings, conditions of chemical analysis need not be too rigid, since a really satisfactory casting will have the required mechanical properties. The important properties are castability, machinability and impact strength.

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J-05013

Extensive savings on machining were realized on this magnetic clutch with Westinghouse investment casting.

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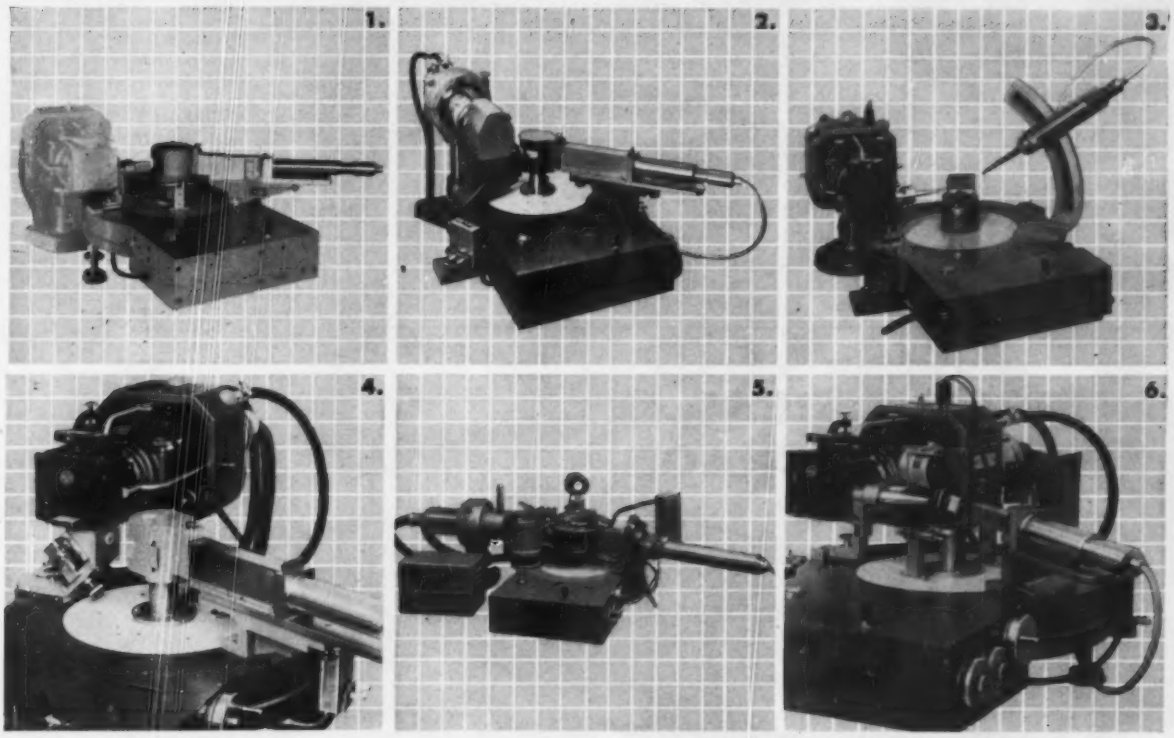
Circle 1176 on Page 48-B

X-RAY DIFFRACTION AND SPECTROSCOPY



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Circle 1177 on Page 48-B

Die Casting . . .

Degassing is not so very important. A reliable test is to fracture a small ingot which will reveal ductility, grain size and freedom from dross.

A chemical composition for magnesium has now been stabilized at 9.0 Al, 0.2 Mn and 0.6 to 0.1 Zn to combine mechanical properties with castability. The usual limitations of magnesium alloys are the need for a sulphur atmosphere and freedom from small inclusions of slag, which will accelerate corrosion.

A careful control of chemical composition in zinc alloys, both of raw materials and of changes during the process, is essential. Spectrographic analysis is required since traces of lead, tin, and cadmium will cause intercrystalline corrosion.

Design of Casting and Die

Design is an essential feature of quality control. Since a thick part will cool more slowly and militate against the advantages of the process, all sections should be of minimum thickness consistent with reasonable ease of casting. Strength should be conferred by ribs and flanges with up to 4° draft per side. They must not be placed opposite on either sides, or hot spots will form and subsequent sink. Thicknesses of 0.040 in. minimum and 0.500 in. maximum are suggested as extremes of variation in section. Fillets are essential to prevent cracks at corners and the following formula is strongly recommended

$$R = \frac{A+B}{3}$$

where R is radius of fillet, A is wall section and B is adjoining wall section.

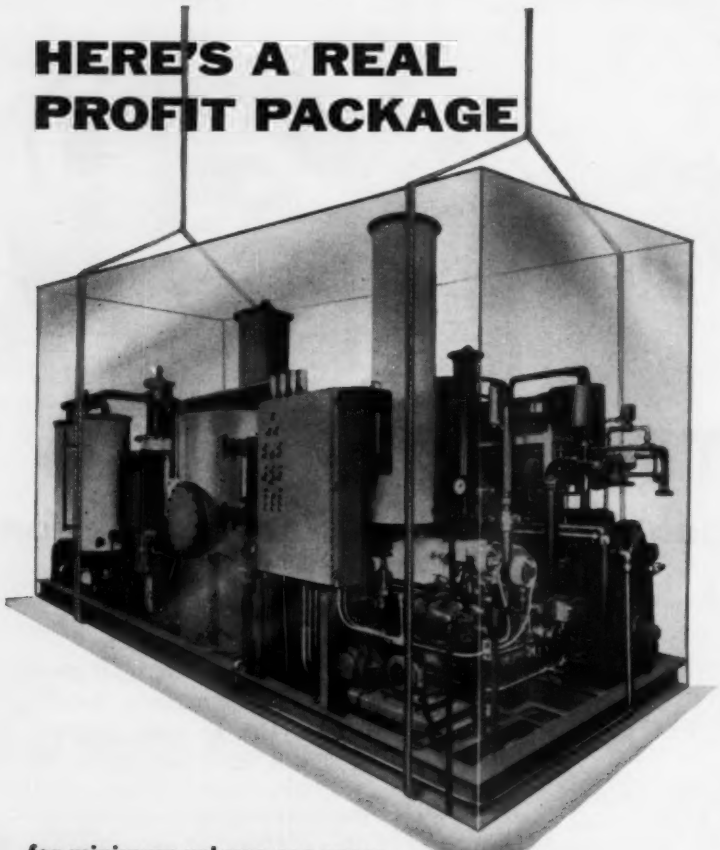
Heat Balance in Die Cavity

Cavities, runners and overflow wells must be arranged in size and place to insure a thermal balance in the die. Solidification must progress continuously, not leaving behind liquid to cause a heat sink. Where this ideal is impossible, liquid metal to provide feed must remain in a blind runner or overflow. The usual conditions which decide the position of a runner are even more important in pressure die castings. Heat content, thermal conductivity, casting temperature and die design all join to control the rate and place of heat abstraction.

A metallurgical factor in the operation is the difference of temperature between the liquidus and the solidus. Eutectic alloys having the minimum practical difference are best for usual sections, but for heavier castings, alloys with a wide freezing range have some advantages. A large gate, slow injection speed and high pressure will promote conditions approaching extrusion.

Flow of Metal Into Cavity

Several theories of metal flow into cavities have been made, and may have limited uses in simple castings. The author finds that the cavity must be filled in 0.2 sec. or less, and that the metal must pass through the gate at less than 3000 ft. per min. There must be minimum turbulence. An etched section of the casting will show the movement in filling the cavity, and will guide in making modifications. The gate is situated at the lowest point in the cross-sectional area gradient of the cast-



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Circle 1178 on Page 48-B

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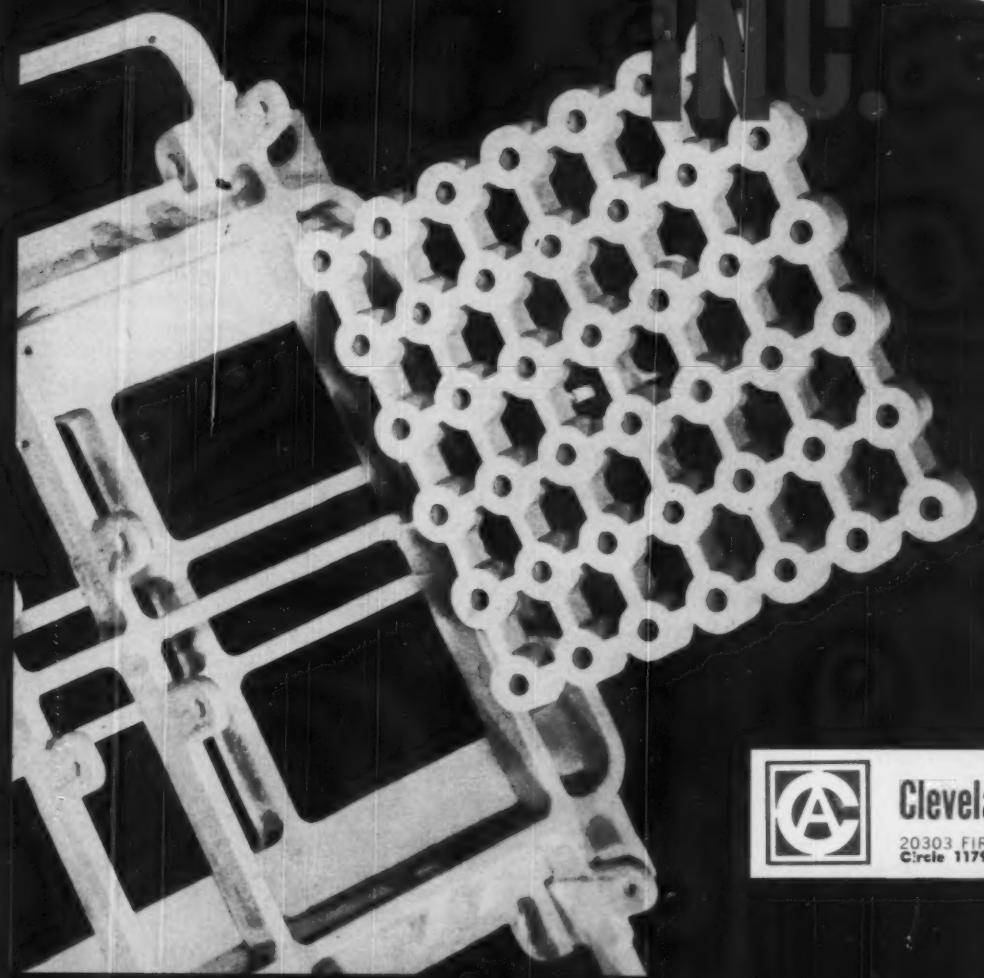

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Circle 1179 on Page 48-B

Die Casting . . .

ing, and multiple gates should be avoided.

Injection Pressure

The comparative effects of pressure from hydraulic power, compressed nitrogen, or a combination of both were explored with special oscillographic equipment. Such equipment is more suited to development than to routine control, but differences, even with identical machine settings, were found to affect quality. The hydraulic power had some advantages due to a slower rate of rise in pressure towards the end of the stroke, so that there is longer time for metal to solidfy at the split lines, and there is greater freedom from random variations.

A fully experienced operator should start a practice with a new die. Injection speed should be adjusted to fill the die in 0.1 sec. for a large and 0.05 sec. for a small casting. Excessive oil stains and flow lines will appear at first. In the flow lines do not disappear when the die is warmed up, the gate should be increased to reduce the flow speed to less than 3000 ft. per min. and marks due to turbulence should disappear. When the die design and rate of flow have been determined, the remaining essential condition is to maintain a steady rate of operation. All phases of machine cycle should have been set by autotimers. The only variable left is concerned with the operator — time for ladling and injecting liquid metal and time between each casting operation for cleaning and dressing the dies and setting valves for water cooling. These jobs should require the minimum number of separate operations and a time study should be made of the general rhythm of the operations. This information should be recorded and maintained in the future. This constant rate of movements is necessary to maintain the controlled thermal conditions. When checks show that quality is deteriorating, metal and die temperatures, injection pressure and speed and times of operations can be compared with the record card, and immediate remedial action can be effective.

J. W. Jones

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During the first six months of 1959, Turco undertook an extensive survey of the phosphate coating market. Hundreds of users of these coatings were interviewed. Thousands of questions were asked. When the answers were tabulated, Turco began the task of building an iron phosphate process to the *exact specifications* called out in the survey.

The new process is now available. It is called Turco Paintite. Paintite has been thoroughly field-tested in the production lines of a dozen Turco customers. It has passed the most severe tests with flying colors. Turco is proud to announce the addition of Paintite to its ten other Turcoat phosphate and conversion coating processes that provide a better bond for organic finishing.

1. **SUPERIOR CLEANING**–Exclusive wetting system provides heavy-duty uniform cleaning. Cleans & phosphates simultaneously.
2. **TEMPERATURE VERSATILITY**–Efficient anywhere within range of 140° to 180°F. Temperature control is not important.
3. **LOW FOAMING**–at any temperature within recommended range.
4. **LESS POST RUST**–Eliminates post rusting problem often encountered with iron phosphate processes.
5. **NO WHITE STREAKING**–Extra free rinsing. Leaves no residue.
6. **ECONOMICAL**–Low in initial cost. Low in maintenance cost. Low in cost per sq. ft. Long-lived, even under mass production use.
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8. **USE VERSATILITY**–used by immersion, spray washer or steam cleaner.
9. **LESS SLUDGE**–less scale. Minimizes clean-up problems.
10. **RESERVE ACIDITY**–combats alkaline water conditions. Constant control not necessary.
11. **SUPERIOR SERVICE**–by Turco's vast network of technically trained servicemen, located in industrial centers throughout the world.
12. **REQUIRES ONLY 3 STAGES**–for dip or spray washing. Can be efficiently used in 5-stage operations, if desired.

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Circle 1180 on Page 48-B

Fabricating Zircaloy-2

Digest of "Fabrication of Zircaloy-2 Channels for Vallecitos Boiling Water Reactor Fuel Assemblies", by C. N. Spalaris, *Nuclear Science and Engineering*, Vol. 6, 1959, p. 37 to 43.

Use of zirconium alloys in reactor components is based mainly on low neutron absorption, good mechanical properties at elevated temperatures, and good corrosion resistance. To retain these properties successfully, they must be maintained during fabrication by techniques which are still in development stages.

Corrosion resistance of Zircaloy-2 in high-temperature, high-pressure water mediums decreases as impurity content, especially nitrogen, increases. Hydrogen and oxygen in excessive amounts are detrimental to the mechanical properties. Obviously, there is a high potential of gaseous contamination during welding. In the channel application, corrosion resistance and mechanical integrity were required in boiling water at 550° F. and 1000 psi.

Zircaloy-2 tends to counteract stress concentrations by excessive spring back after mechanical forming. This poses a real problem in fabricating square channels (3 by 3 in.) with a maximum deviation throughout the 42-in. length not greater than 0.1 in. from a combination of straightness, squareness, and bow requirements.

Channels were formed by cutting strip 0.035 in. thick (from vacuum melted ingot) to length and bending

METALGRAMS

UNION CARBIDE METALS

. . . news of "Electromet" ferroalloys and metals

SEPTEMBER 1960

MORE ELECTROLYTIC MANGANESE -- To meet the increasing demand for "Elmang" electrolytic manganese metal, Union Carbide Metals has expanded its cell capacity by 20 per cent. Hence, a larger supply of this high-purity product (99.9 per cent minimum manganese) is assured for additions to steel, copper, and aluminum. Also of interest: (1) The metal is now available in 50-lb. bags for convenient, accurate additions. (2) The 600-lb. drums of "Elmang" manganese are now color-coded to allow easy identification of the regular, dehydrogenated, and nitrogen-bearing grades. Write for new specification sheet, F-20,151.

* * *

ALLOYS FOR BASIC-OXYGEN STEELMAKING -- Interest has been focused on the basic-oxygen process because it can make high-quality steel rapidly and at low cost. Small accurate alloy additions can be made to the ladle of basic-oxygen heats with bagged alloys. Where large chromium and manganese additions are required, "Chromtemp" ferrochrome and "Mantemp" ferromanganese can be added to the ladle. All these unit-weight packages allow precise analysis control. Also, furnace time is not required to dissolve the alloys in steel. Your UCM representative will be glad to give you further details. Also, write for the article, "O_2 Steelmaking," in the Spring issue of UNION CARBIDE METALS REVIEW.

* * *

SILICON IN COPPER -- First developed in France in 1881, silicon bronze is growing rapidly as a corrosion-resistant material for vessels, tubing, marine and poleline hardware, and electrical conduit. Up to 3 per cent silicon provides strength and hardness. For such additions, Union Carbide Metals offers a low-aluminum silicon metal. Since aluminum makes bronze sluggish in pouring, this special grade contains a maximum of 0.10 per cent aluminum. For further information, contact your UCM representative. Also, write for the article, "Silicon Strengthens Copper," in the Winter 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

SERVICE ON THE MOVE -- Every year, experienced metallurgists of UCM's Metallurgical Service Division travel tens of thousands of miles to customers' plants. Their mission: to provide on-the-site help on the use of ferroalloys and alloying metals in melting. As an example, a Metallurgical Service representative worked with Electric Steel Foundry Company of Portland in evaluating the new fast-dissolving "Simplex" ferrochrome in stainless steel. The joint effort showed that 5- to 7-minute savings in furnace time could be made per 2,000 lb. heat. For a picture story of this cooperative service, write for "Service on the Move" in the Winter 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

HIGHER DUCTILITY WITH CALCIUM-SILICON -- Two Midwestern steel foundries recently obtained data on Grade B steel castings made with and without calcium-silicon. In one test of 91 production heats, all of the heats treated with calcium-silicon and aluminum produced castings with satisfactory ductility. As a comparison, over 25 per cent of the heats deoxidized only with aluminum failed to meet reduction-in-area specifications. In another test of 20 production heats, a 15 to 20 per cent improvement in ductility (% RA) was reported. Further data can be obtained by writing for the article, "Calcium Improves Ductility of Steel Castings," in the Summer 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

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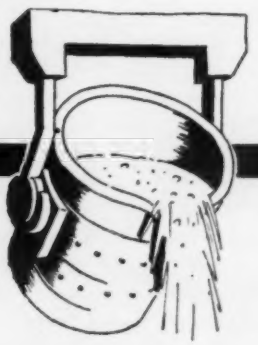

Pyro-Eye is designed for in-plant and laboratory temperature measurement of incandescent molten metal, glass, ceramics, billets, rods, sheets, refractories and many other high temperature applications.

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Circle 1181 on Page 48-B

Zircaloy-2 . . .

at room temperature over a rubber or metal die to L-shaped pieces. Small average grain size, smallest possible amount of cold work, and minimum level of gaseous impurities are required for good cold forming.

Two diagonally opposite corners are welded to form a square in a fixture having an expanding mandrel and locking V-clamps as principal parts. Although Zircaloy-2 reactor components are usually welded in a controlled atmosphere chamber, these channels were welded using a standard traveling shield with pure helium flowing through the torch, trailing shield, and mandrel. All void spaces were continuously purged with pure helium during welding to preclude contamination by air.

The majority of channels produced were dimensionally acceptable with many having deviations well below the allowable limit. The welded joints had excellent resistance to corrosion by high-temperature, high-pressure steam. Irradiation does not appear to produce distortion of the channel or unusual corrosion in the bends and welds.

The evidence indicates that Zircaloy-2 parts of various shapes and sizes can be welded outside a controlled atmosphere chamber and have adequate corrosion resistance and strength, if enough inert gas covers the weld. C. O. SMITH

Brittle Fracture in Ductile Steel

Digest of "Where We Stand in Design With Brittle Fracture", by B. L. Averbach, Publication No. SSC-120, Feb. 23, 1960, Ship Structure Committee, U. S. Coast Guard Headquarters, Washington, D. C.

THIS DOCUMENT emphasizes that the mode and appearance of fractures in ship plate (containing less than 0.25% carbon used in as-rolled or in normalized condition with ultimate strength around 60,000 to 70,000 psi., and quite ductile so that the tensile stress-strain curve shows an "upper" and a "lower" yield point) is quite different from that of alloy steel heat treated to high strength (on the order of 220,000 psi. elastic limit) or of austenitic alloys strength-

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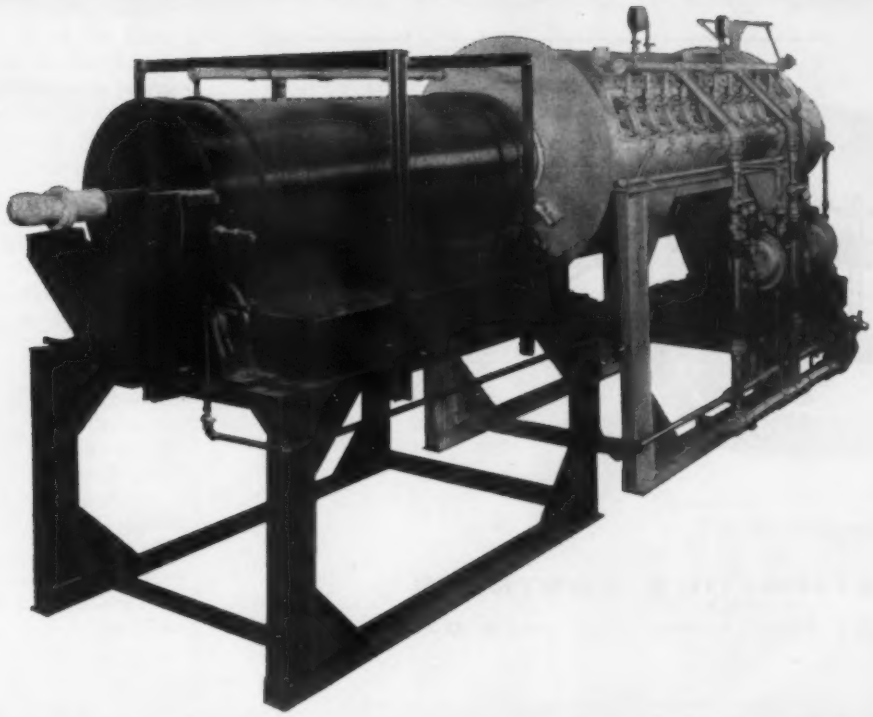

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Brittle Fracture . . .

ened by severe cold work. The devices and theories used by students of the high-strength sheet were discussed in some detail in a series of articles in the August 1960 issue of *Metal Progress*. The success attendant upon efforts to build tougher ships and tankers was described by Harris and Williams in "Tough Ship Plate", *Metal Progress*, April 1959, p. 66.

In the document now under review, Professor Averbach emphasizes that the brittle fractures in low-carbon steels include much cleavage along the (100) planes of the ferrite crystals. This does *not* occur in metals with face-centered cubic crystals. In ship plate the appearance of a brittle fracture is also quite characteristic. "A chevron pattern points back to the origin of failure. This appears to be associated with a crack that proceeds in a discontinuous fashion – that is, in a sequence of initiations ahead of the main crack followed by a breakdown of the intervening material to form a union with the principal crack. The crack front is not straight, the main fracture front extending in the center well in advance of the surface trace. In mild steel, cleavage microcracks are initiated repeatedly ahead of the main crack, and this provides the discontinuous feature of the traveling crack. The problems of initiation and propagation of cleavage cracks thus tend to merge, since conditions for the initiation of a cleavage microcrack may be very close to those required for the discontinuous propagation of a gross crack."

Other differences in brittle failure of ductile steels and high-strength alloys are worth noting:

The characteristic cleavage along (100) planes is intensified by presence of interstitial elements such as carbon and nitrogen.

While in both classes of materials the tendency toward brittle fracture goes up as the temperature goes down, the "transition" temperature is much higher for ferrite steels than for austenitic alloys.

The yield strength of ferritic steels rises sharply as testing temperature drops below 70° F. – a phenomenon which is relatively unimportant in austenitic alloys.

Cleavage failure is favored by high strain rates, and the apparent yield strength of ship plate is raised considerably if the load is very rapidly applied, whereas the yield of heat treated high-strength steel is relatively insensitive to rate of strain.

In view of these more or less contradictory experimental facts, it is not surprising that the solid-state scientists have not yet come up with a theory and equations which fit. The author points out that Griffith's equation neglects the fact that plastic flow occurs prior to cleavage failure. Orowan modified the equation to include this requirement, but this still neglects the influence of temperature. Stroh, as well as Zener, writes an equation based on the concept that a pile-up of dislocations in a slip band is required to start a cleavage crack. One compelling objection to this is that cracking is produced exclusively by shear stress, whereas we know that normal tensile stresses effectively raise the cleavage transition. Finally, Cottrell assumes that dislocations traveling on two (110) slip

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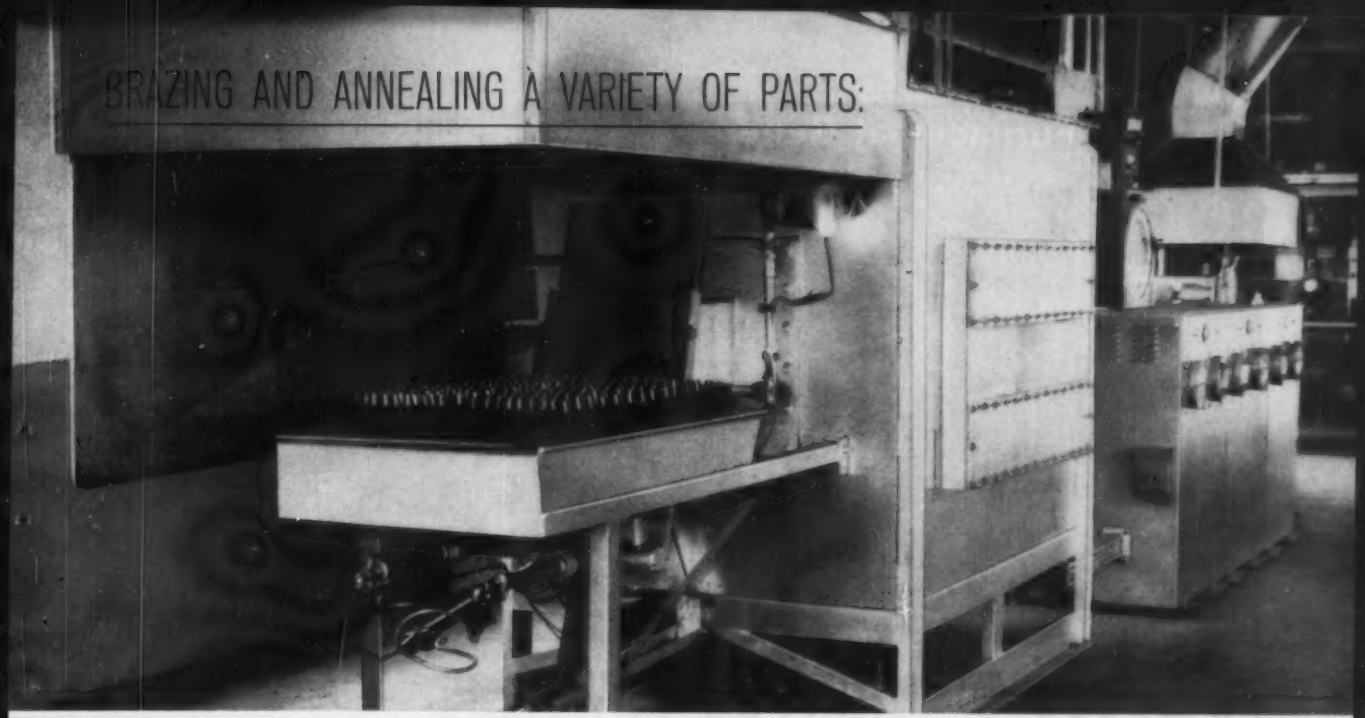
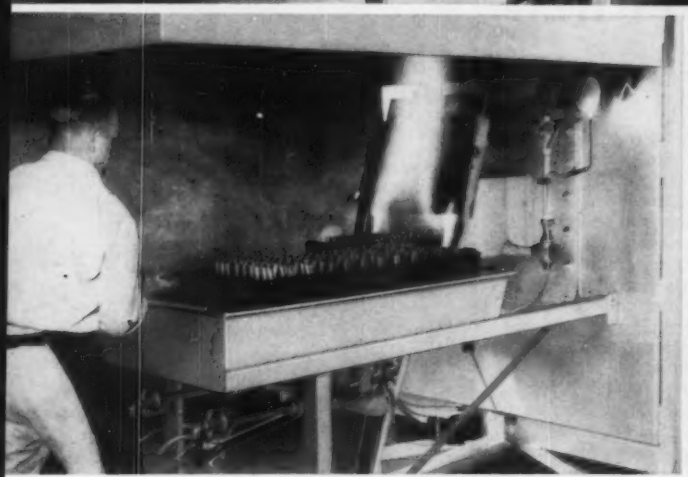
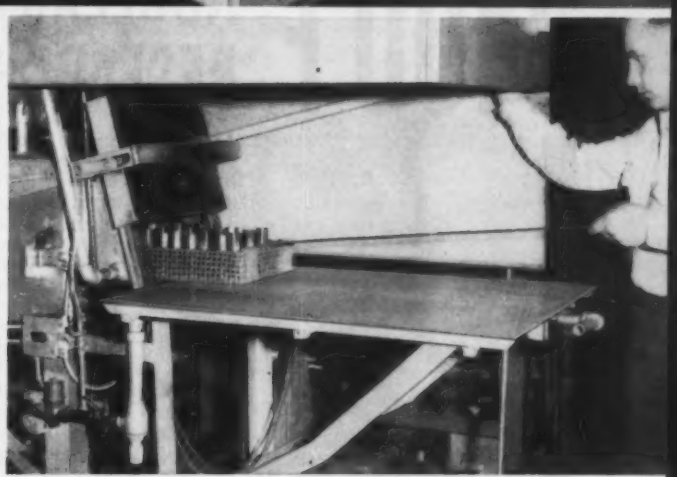
Circle 1183 on Page 48-B

BRAZING AND ANNEALING A VARIETY OF PARTS:





Basket of parts is pushed from the end table through gas flame curtain of charging door into heating chamber. The charging door and inner refractory doors of heating chamber are pneumatically-operated.



Clean, bright brazed parts are drawn from the water-jacketed cooling chamber at the exit end of furnace. In this instance, four baskets can be cooled while one basket is being treated in the heating chamber.

COSTS MINIMIZED IN BUSY JOB SHOP

Processing metal parts for several manufacturers on a contract basis, Edward E. Russell Co., Wallingford, Conn. uses two Harper box furnaces for brazing with copper and silver alloys as well as for annealing. Parts from 1/4" in diameter up to 11" x 7" x 36" are treated at temperatures up to 2350°F. Each furnace handles up to 200 lbs./hr. net.

The first Harper furnace (shown above) went into operation in 1951 and the second during 1953. Both have been in continual use since installation with practically no lost time for maintenance.

The company reports that the furnaces have "not only proved extremely economical, but are exceptionally versatile, easy to control and productive of high quality work."

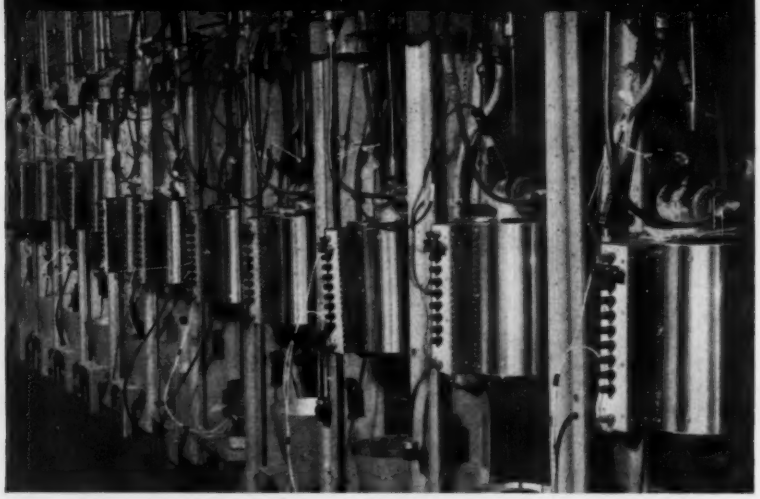
The next time you're considering the purchase of a furnace for brazing, sintering or annealing, you'll find it worth your while to discuss job requirements with a Harper representative . . . for Harper can build the furnace best suited to your needs: box, pusher, mesh belt hump or straight-thru, roller hearth, bell, elevator or pit. To obtain detailed information, write: Harper Electric Furnace Corporation, 40 River St., Buffalo 2, N. Y.

HARPER ELECTRIC AND GAS FURNACES

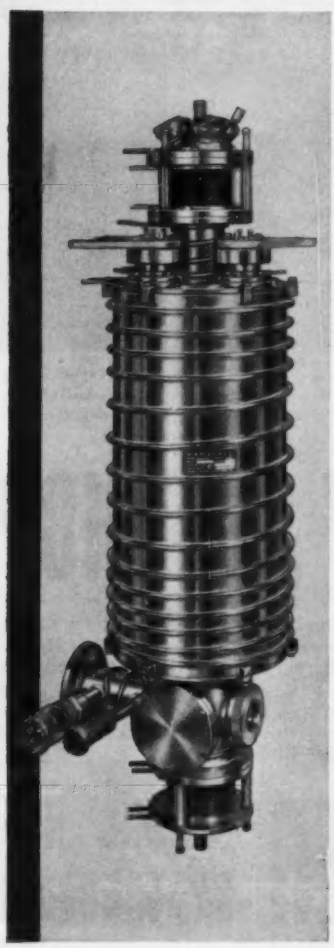
FOR BRAZING, SINTERING, BRIGHT ANNEALING, AND FORGING IN RESEARCH AND PRODUCTION

Circle 1184 on Page 48-B

Marshall Furnaces at General Electric



2400°F NUCLEAR POWER RESEARCH



At GE's Aircraft Nuclear Propulsion Department in Cincinnati, Ohio, more than 50 Marshall furnaces help test materials being developed for aircraft nuclear power plants. The furnaces are components of GE-designed rigs used for stress-rupture, creep, thermal expansion, cyclic temperature and cyclic stress testing. Tests are conducted, within air, on cermets, intermetallics, true ceramics and alloys. Marshall furnaces accurately maintain set temperature levels as high as 2400° F., within ±3° F.

Marshall offers a complete range of tubular, resistance wound, shunt-type furnaces for many uses up to 2600° F. Furnaces feature *uniform temperature or regulated temperature gradient* and *rigid zone control to ±3° F.* (under certain conditions, temperatures can be held to ±1° F.!). Test duration can range from moments to 10,000 or more hours. Furnaces are compactly designed, and include standard mountings for easy assembly to testing machines. Models are available from 1″ to 12″ I.D. or more, and from a few inches to several feet long.

Marshall also offers special vacuum tensile and creep testing furnaces for 3000° F. and 4000° F. Hot-hardness testing models available to 3000° F.

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Stress-rupture rigs at General Electric (at top). Marshall 4000° F. vacuum testing furnace (left).

Circle 1185 on Page 48-B

Brittle Fracture . . .

bands meeting at an angle form a giant dislocation which in effect pries open the metal into a crack leading away from it. Terms in the final equation take account of the grain size and testing temperature.

Professor Averbach thinks that some further modifications of the Cottrell theory are required to explain experimental results recently acquired, particularly the factor stating the "effective surface energy", including plastic work, which is now obtained empirically from the test data. "Nevertheless, the dislocation picture of brittle fracture has been very helpful in providing a theoretical framework for the fracture mechanisms, and it is expected that these concepts will be developed."

E.E.T.

Plating Pure Chromium

Digest of "Electrodeposition of High-Purity Chromium", by F. E. Block, P. C. Good and G. Asai, *Journal* of the Electrochemical Society, Vol. 106, January 1959, p. 43-46.

THE ELECTROLYSIS of chromic acid solutions was selected for study as a method of preparing high-purity chromium because metallic impurities may be excluded easily and gaseous impurities remain at very low levels. Although a low current efficiency is obtained in electrowinning chromium, and chromic anhydride is an expensive reagent, this method was adopted because the metal could be produced sufficiently pure to permit a study of its properties without additional purification steps which are expensive.

The electrolytic cell was a steel tank lined with polyvinyl chloride; it had an aluminum cathode and lead anode. The electrolyte consisted of varying proportions of chromium trioxide, distilled water and sulphuric acid. Provisions were made to maintain the electrolyte at a constant level during the operation of the cell. Since the electrolyte was used repeatedly, impurities were removed before each run by contacting the solution with a cation-exchange resin. The cathode current density was varied from 340 to 1100 amp. per sq.ft. The bath was water cooled and held constant at a tem-

BLH BUILDS WORLD'S LARGEST LOAD CELL TO ACCURATELY MEASURE 1,500,000-LB. ROCKET THRUST

America's first rocket engine with a launching thrust of 1.5 million pounds is now being developed by Rocketdyne, a division of North American Aviation, Inc.

One of the most critical factors in the successful firing of a rocket or missile is the exact determination of weight and thrust. Present operational rocket engines are tested for weight and thrust by using a series of load cells of no more than 100,000 pounds capacity each, along with allied instrumentation for computing data from the several sources.

Now the BLH development of a single functional cell with a 1.5 million lb. capacity will permit evaluation of total weight and thrust from one source, reducing the number of possible sources of error. Calibration and testing by the National Bureau of Standards has proved the load cell and its instrument system to be accurate to ±0.10% of reading over the full scale from one-tenth to full capacity. The complete system will become part of Rocketdyne's high-thrust test area at Edwards Air Force Base, Calif.

BLH experience and capabilities in force and strain measurement are available for your use, whether in pioneering efforts such as this one, or in the improvement of existing measurement applications. Write for additional proof of BLH capabilities . . . or contact your nearby BLH sales engineering representative for application engineering service.

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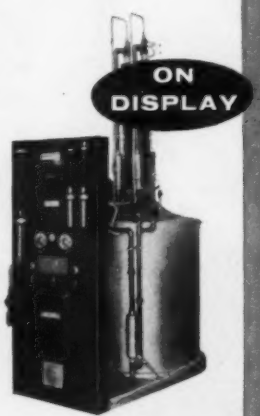

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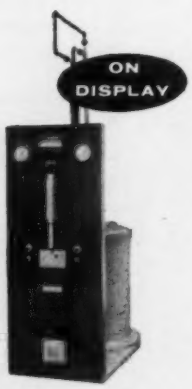
U.S. Patent No. 2,802,725 (Kappel)



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Circle 1187 on Page 48-B

Plating . . .

perature of 85 to 90° C. (185 to 195° F.) which was near the boiling point of the electrolyte. This temperature was chosen since previous work had shown that high temperatures favored lower oxygen contents.

During electrolysis, the deposit appeared first as a smooth surface having a matte finish but as deposition continued it changed to a more nodular form which subsequently grew quickly into long dendrites. The initial deposit was tightly adherent whereas the dendrites broke from the cathode and dropped to the bottom of the cell. The dendrites could be recovered as metal but it was necessary to treat them with nitric acid to remove lead chromate which had sloughed off the anode and mixed with the dendrites. Also, the dendrites contained much more oxygen than the adherent deposits. For this reason, attempts were made to minimize the growth of dendrites. This could be accomplished by changing cathodes at shorter intervals, but the thin deposits obtained by doing this were difficult to remove. It was found that a deposition interval of 72 hr. produced a highly stressed deposit between 1/16 and 3/32 in. thick which was readily removed by striking the cathode with a sharp blow.

The experimental results showed that it was possible to minimize the dendrite growth by operating at low current densities. It was also found that the current efficiency was independent of the current density at constant bath composition and that maximum efficiency was obtained when baths were used having CrO_3 to SO_4 ratios of approximately 50. Usually, the deposit which was removed from the cathode was found to contain between 50 and 250 ppm. oxygen and less than 20 ppm. nitrogen. The dendrites contained from 260 to 1170 ppm. oxygen. Spectrographic analysis indicated trace amounts of an aluminum-iron compound and silicon.

For physical testing, the deposits were consolidated by the inert-atmosphere, cold mold, arc melting technique. Tensile tests were made on wire specimens prepared from the arc-cast ingots. The ingots and swaged wires were protected during processing by sheathing either in

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Circle 1188 on Page 48-B

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Plating . . .

stainless steel or mild steel. To obtain full ductility in the wires, it was first necessary to remove a thin surface layer by etching. The results of tensile tests at 25° C. (75° F.) on 50% cold drawn wires on specimens prepared from two ingot melts indicate that chromium containing less than 50 ppm. of nitrogen is ductile while chromium containing on the order of 200 ppm. nitrogen has no ductility. A. J. LENA

Creep-Rupture of Nickel-Chromium Alloys

Digest of "The Creep-Rupture Properties of 80 Ni-20 Cr Alloys", by Robert Widmer and N. J. Grant, A.S.M.E. Paper No. 59-A-119.

THE CREEP BEHAVIOR of many metals, in terms of either strength or ductility, can be markedly influenced by minor constituents and impurity elements. For instance, small amounts of lead, bismuth, sulphur, among others, have a pronounced effect on the grain-boundary behavior of many metals, causing a marked reduction in their properties. On the other hand, boron and zirconium have a favorable effect on the strength and ductility of high-temperature nickel-chromium alloys hardened with titanium and aluminum. This investigation was undertaken to determine the effect of various minor constituents such as sulphur, silicon, manganese and possible tramp elements on the creep-rupture and creep behavior of a series of 80% Ni, 20% Cr alloys over a 1200° to 1800° F. range.

Two vacuum melted and three air melted alloys were chosen for this investigation (see Table). Alloys 1 and 2 were vacuum melted; 3, 4, and 5 were air melted. Alloys 4 and 5 were deoxidized by the addition of aluminum, titanium, boron and magnesium, whereas calcium was used for alloys 1, 2, and 3.

The alloys were heat treated to obtain an A.S.T.M. grain size of 3 to 4. Afterwards they were held at 1500° F. for 24 hr. to prevent any possible aging. Test bars 0.25 in. in diameter by 1 in. gage section were then machined from each alloy.

Constant-load creep-rupture tests were performed at temperatures ranging from 1000 to 2000° F. with the majority of the tests being conducted at 1200, 1500, and 1800° F. Stresses were carefully selected to produce failures in times ranging from a few seconds to several thousand hours. Elongation and reduction of area values at fracture were determined for all specimens. In addition, they were examined microscopically to determine what types of structural changes had occurred.

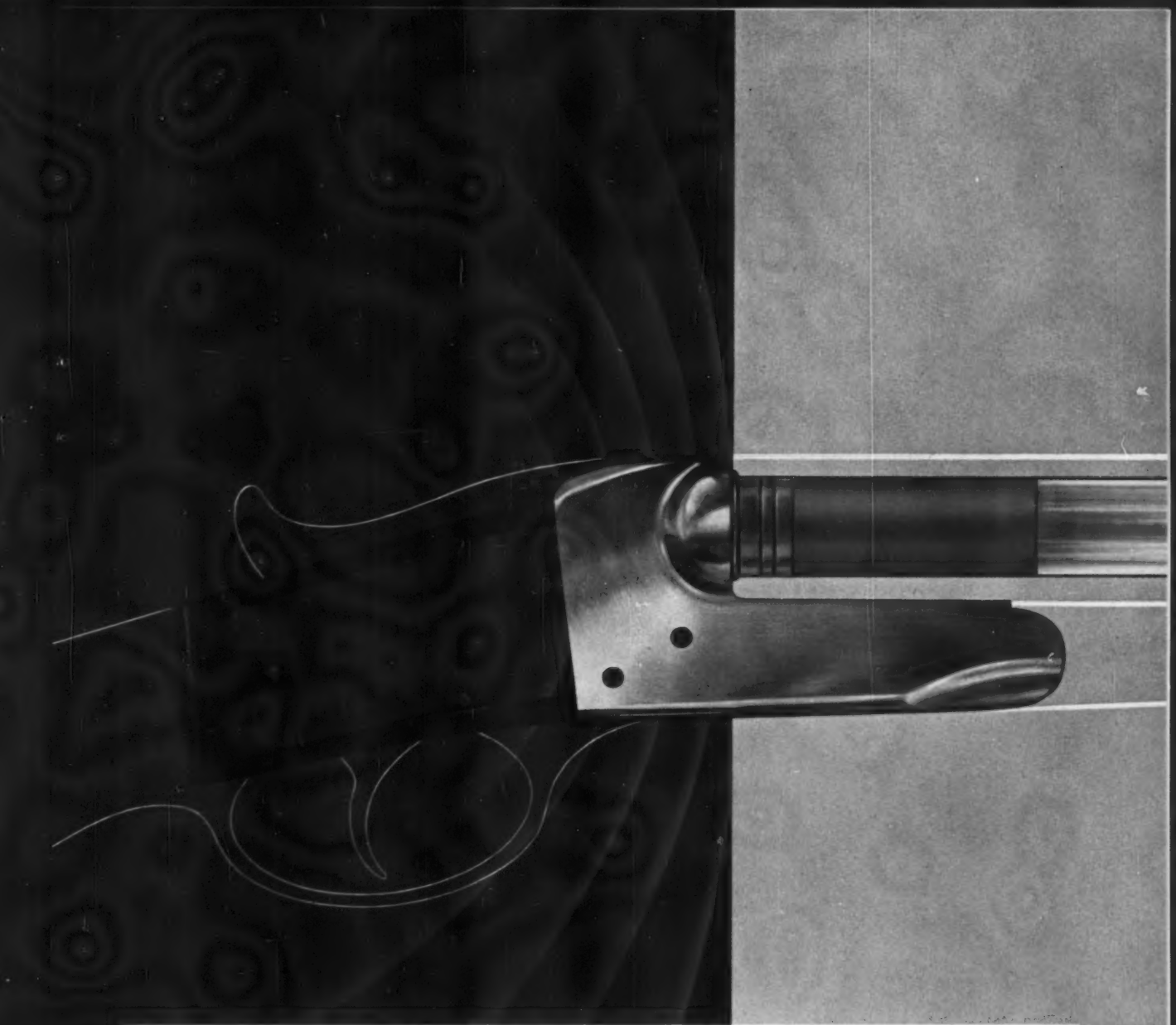
The data obtained in these tests were plotted in the form of creep and rupture life curves to facilitate this study. A careful study of the test results indicated that processing variables and minor constituents had a significant effect on the ductility of these alloys, but little or no effect on the rupture life. This was demonstrated when curves depicting first and second-stage creep revealed very little difference between vacuum melted and air melted material which was tested in air. However, the ductility of the vacuum melted material was two to three times greater than that of the air melted material. This was true at all test times and temperatures. This indicated that air melted material would function as well as vacuum melted if the maximum permissible deformation did not exceed 1%. However, where a safety factor is needed, the vacuum melted material is superior.

A comparison of the ductilities of the five alloys revealed that alloy

Table I – Chemical Analysis of Alloys

ALLOY*	CR	C	S	P	SI	FE	MN
1	19.17	0.02	0.011	<0.003	0.012	0.07	0.11
2	19.59	0.03	0.003	<0.003	1.33	0.10	0.27
3	19.45	0.02	0.002	<0.003	1.38	0.12	0.01
4	19.98	0.02	0.002	<0.003	1.22	0.34	<0.01
5	19.96	0.02	0.004	<0.003	0.30	0.60	<0.01

*Balance of all alloys was nickel.



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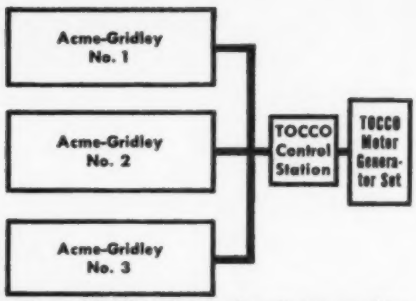

Plan view of TOCCO-equipped automatic screw machine installation for hardening collars on vane pump shafts.

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Circle 1190 on Page 48-B

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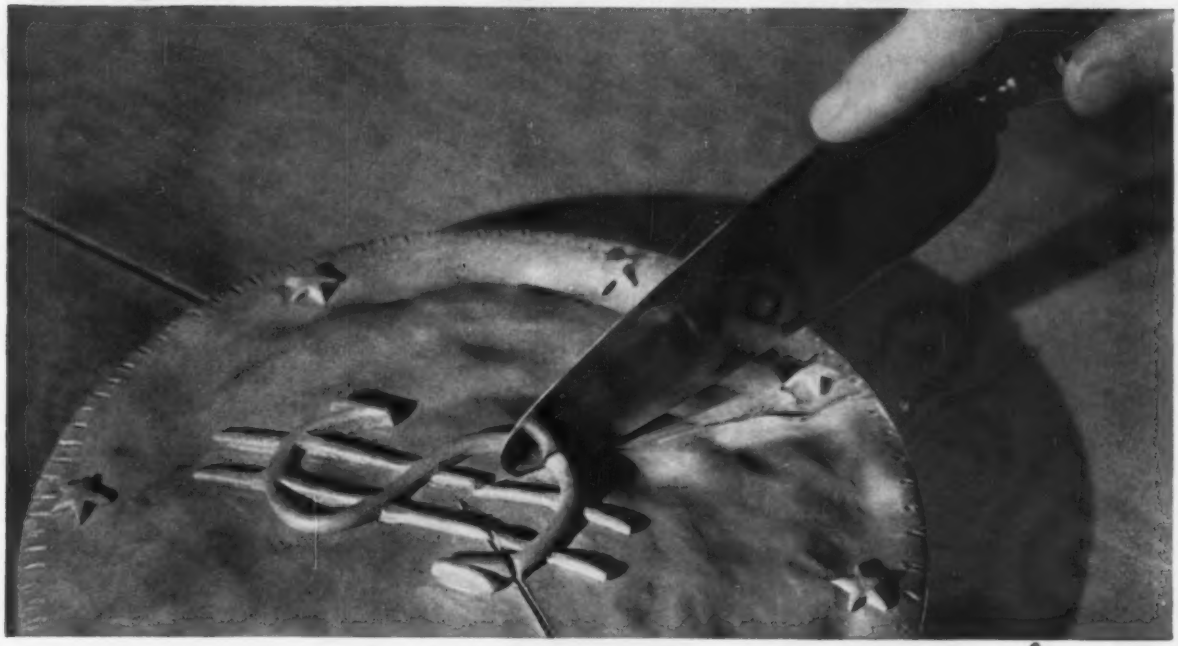

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Circle 1191 on Page 48-B

Creep-Rupture . . .

2, a high-silicon vacuum melted material, had the greatest ductility. This was partially attributed to the elimination of the tramp elements and to the diminution of the contaminating constituents which are normally present in air melted alloys. Other factors affecting the ductility were manganese-sulphur ratio and silicon content.

BERNARD TROCK

Brazing Superalloys

Digest of "New Development in Brazing High-Temperature Nickel-Base Alloys", by E. H. Kinelski and J. B. Adamec, *Welding Research Supplement*, December 1959, p. 482-s–486-s.

THE TECHNICAL LITERATURE on the brazing of nickel-base alloys is extensive. These alloys have been furnace brazed with a number of techniques, and the advantages of using preplaced nickel powder has been demonstrated with Inconel "X". This development was pursued to evaluate how successful it would be on other nickel-base alloys.

Programs devoted to the evaluation of brazing alloys require a simple specimen of screening tests. A T-joint was found to be most useful while the most satisfactory specimen for high-temperature tensile-shear was the plug-and-cylinder type. This specimen was used for short-time tests as well as stress-rupture tests.

To establish a base line for evaluating experimental brazing alloys, it was necessary to determine the tensile shear strength of Inconel "X" brazed with commercial alloys. Four alloys were used: 66 Ni, 20 Cr, 9 Si, 4 Fe; 72 Ni, 16 Cr, 4 Si, 4 Fe, 4 B; 88 Ni, 12 P; and 33 Pd, 64 Ag, 3 Mn. One-half of the specimens were plated with nickel; the others were brazed with a borax flux. Brazing powders were applied as a slurry with an acrylic resin binder. The highest shear strength at 1200° F., 41,100 psi., was obtained from the Ni-Cr-B brazing alloy. New specimens brazed with this alloy were evaluated for stress-rupture with the following results:

TEMPERATURE TEST	100-HR. LIFE
1200° F.	27,000 psi.
1500	6500

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The successful fabrication of modern honeycomb structures has been dependent, in part, on the ability to braze 17-7 PH stainless steel with a self-fluxing copper-nickel (plus lithium and boron) alloy in an argon atmosphere. More recent self-fluxing alloys have not been completely satisfactory because of segregation. Furthermore, there has been a need for an alloy which would be self-fluxing on nickel-base alloys containing aluminum and titanium, would yield brazements exhibiting high strength at elevated temperatures, would be "nonaggressive", and would not form intermetallics with the base metal.

The palladium-nickel system provided a good base for such an alloy. Additions of lithium and boron provided deoxidizers for the palladium-nickel, reduced the melting temperature, and provided self-fluxing characteristics. Researchers found that lithium or boron, either alone or in combination, provided the desired

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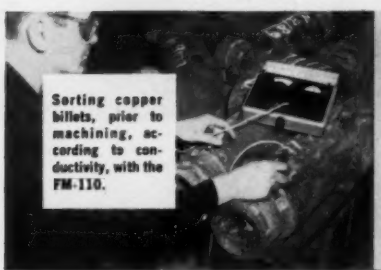

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Circle 1192 on Page 48-B

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Circle 1194 on Page 48-B

Brazing . . .

self-fluxing characteristics in furnace brazing with tank argon. However, the best experimental composition for brazing Inconel "X" was found to be 60% Pd and 40% Ni with 0.05 to 0.30% Li and 0.01 to 0.10% B.

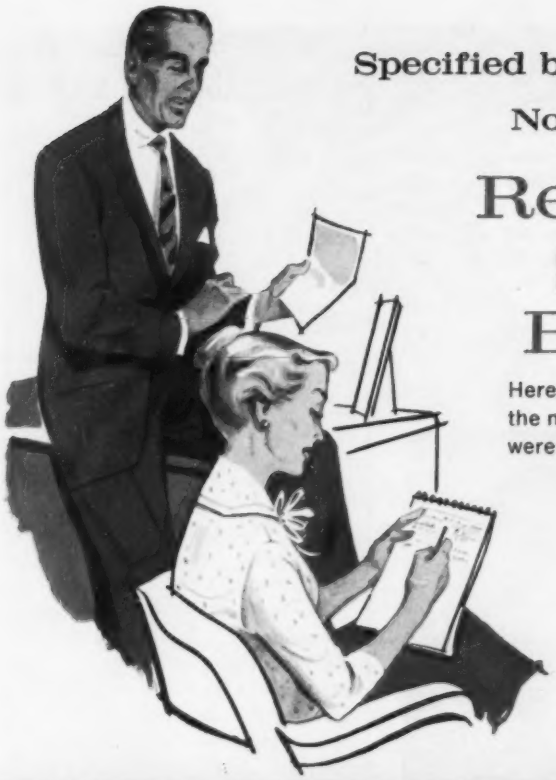
The T-joint brazing test was used to determine wettability and fillet-forming characteristics of the experimental alloy. Following are the results of T-joint tests on several nickel-base alloys in an argon furnace atmosphere:

Alloy	Brazing Temp.	Flow Length
Inconel "X"	2200° F.	3 in.
Inconel "700"	2250	1⅛
Inconel "901"	2250	1¼

Short-time tensile shear tests at 1200° F. on Inconel "X" brazed at 2300° F. with the new alloy revealed an average shear strength of 30,530 psi. Stress-rupture tests on tensile-shear specimens gave values of 18,000 psi. at 1200° F. and 1500 psi. at 1500° F. for 100-hr. life.

There has been some interest in the use of metals placed on the area to be brazed to promote flow of the brazing alloy. During the experimental work on the palladium-nickel alloy, workers noted that when a brazing alloy did not flow into a fillet in a T-test, it did flow along the nickel wire holding the assembly together. Subsequent experiments with Inconel "X", a commercial nickel-chromium-boron brazing alloy and a nickel wire placed in the joint showed that the alloy flowed the entire length of 3 in. when brazed in tank argon. Furthermore, wherever the nickel wire touched the Inconel "X", alloying took place between the brazing alloy and the base metal. It was also found that 0.00075-in. nickel foil and carbonyl-nickel powder made into a slurry with an acrylic-resin binder were equally good when either was preplaced in a T-joint of Inconel "X". It was also found that the placement of the braze alloy alone without the nickel would result in a brazed joint. When the alloy was placed only at one end of the joint, no flow would take place.

Preplaced nickel powder on Inconel "X" T-joints permitted flow of the braze alloy when a hydrogen atmosphere was used rather than



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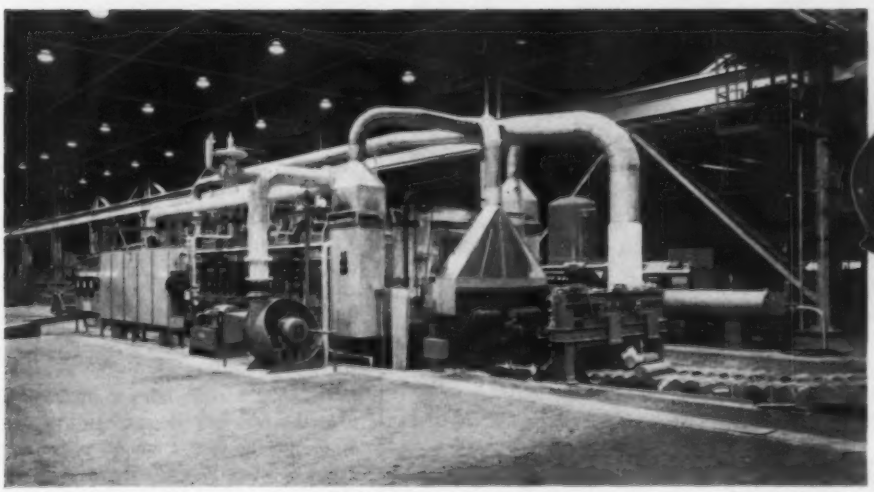

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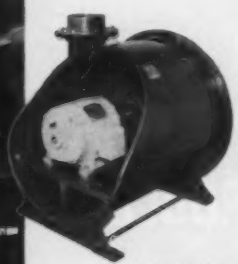

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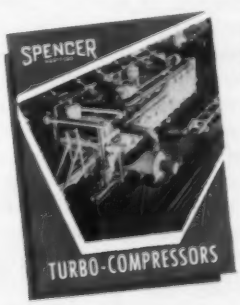

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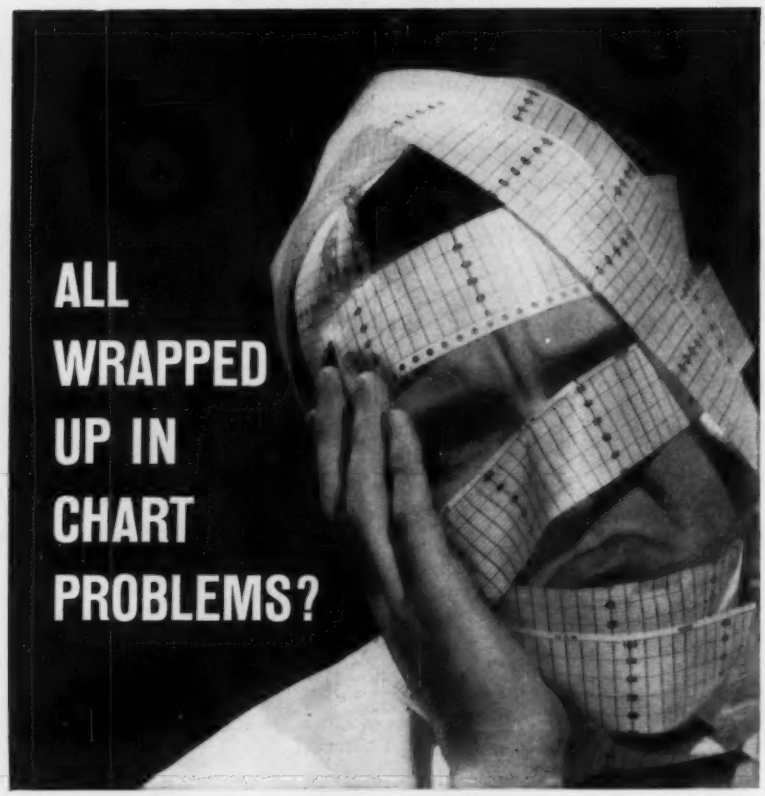
Brazing . . .

argon; however, no alloying was noticed. T-tests using preplaced nickel powder were equally successful on Inconel "700", Incoloy "901", and Inconel "713 C" when brazing was carried out in argon. Again, a hydrogen atmosphere was unsuitable. Tensile-shear tests of Inconel "X" brazed with nickel-chromium-boron brazing alloy and preplaced nickel powder gave an average shear strength of 31,400 psi. at 1200° F.

This investigation has shown that argon is the preferred atmosphere for brazing nickel-base alloys. The excellent flow and wettability of the palladium-nickel-lithium-boron alloy minimizes the danger of unbrazed areas. Furthermore, the application of nickel powder to the braze area also minimizes the chance of unbrazed areas.

R. F. HARTMANN



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Circle 1196 on Page 48-S

Effect of Pressure in Consumable Arc Melting

Digest of "Some Effects of Pressure on Consumable Electrode Arc Melting", by J. W. Suiter, *Journal* of the Electrochemical Society, Vol. 106, January 1959, p. 47-49.

THIS PAPER REPORTS the effects of varying the argon pressure in the range of 1×10^{-3} to 650 mm. of mercury on the weight of metal melted per unit of energy dissipated when melting titanium and steel in a consumable electrode arc furnace.

Titanium electrodes were prepared by welding compacts of sponge titanium. Mild steel electrodes consisted of rolled bars. During melting, the feed rate of the electrode was adjusted by the operator while observing the arc voltage pattern on an oscilloscope, and also the arc voltage and current as indicated by conventional meters. Power for melting was supplied by three motor generator welding machines, and the same generator settings were used in all experiments. The desirable arc length was such that the pattern on the oscilloscope indicated the presence of occasional, momentary dead shorts. It was not possible to measure such an arc length, but it appeared to be less than 0.5 in. For some melts at pressures of 25 and 10 mm. of mercury, a long arc length of 3 in. was deliberately maintained so as to investigate the effects of positionally unstable arcs on the weight of metal melted per unit of energy dissipated. The presence or absence of positionally unstable arcs were observed through a sight glass.

In the pressure range of 10 to 650 mm. of mercury, a static pressure of argon was used, but it was necessary to remove gas from the system while melting to maintain a constant pressure. The pressure which was measured in the body of the furnace did not indicate accurately the pressure in the melting region when melting titanium electrodes at very low pressures due to the presence of volatile constituents such as magnesium and magnesium chloride. Energy dissipated during melting was calculated from the voltage, current and time of melting operation.

As for the results when the pressure was reduced from 650 to 10 mm., the weight of metal melted in-

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Circle 1197 on Page 48-S

Arc Melting . . .

creased rapidly but at lower pressures, the increase was less rapid. Others have suggested that this effect was due to positionally unstable arcs. The author confirmed this in experiments with a long (3 in.) arc length. At a pressure of 25 mm., melting with a long arc had little effect on the weight of metal melted per unit of energy, but at 10 mm. pressure, the weight of metal melted was less with a long arc than with a short arc. There was also a large increase in the amount of positionally unstable arcs with the long arc length.

The effect of pressure on the weight of titanium melted with electrodes of positive polarity was less than melting with negative polarity. Thus, at low pressures, the weight of metal melted per unit of energy dissipated was less with electrodes of positive polarity; this was reversed near atmospheric pressure.

For steel the results are similar to those of titanium except that the weight of steel melted at all pressures was greater than that of titanium. A long arc at a pressure of 8 mm. of mercury led to positionally unstable arcs, and a decreased weight of steel melted per unit of energy dissipated. As with titanium, the positionally unstable arcs could be avoided by short arc lengths in which instance no decrease in melted weight was observed.

The author concludes that at low pressures, the atmosphere in which melting occurs had little effect on the weight of metal melted per unit of energy dissipated. The same trend was observed at high pressures where argon was used as at low pressures when the furnace was evacuated continuously. Furthermore, the steel electrodes contained very little volatile material and the composition of the gas in the melting region differed greatly from the gas composition when melting titanium electrodes. These changes in the gas composition in the melting region appeared to effect neither the behavior of the arc nor the weight of metal melted per unit of energy.

A. J. Lena

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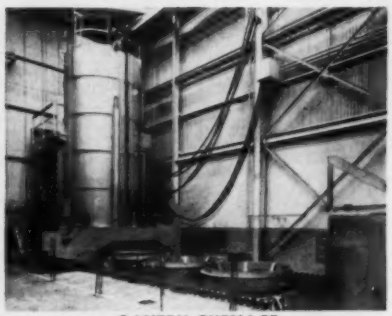

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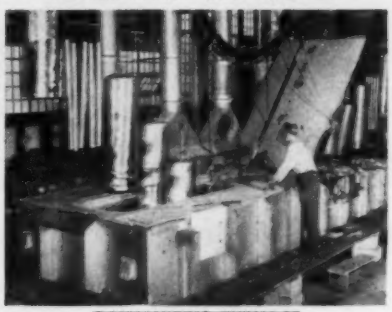

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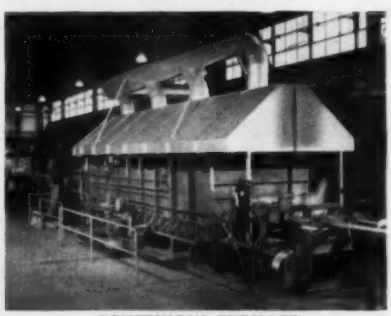

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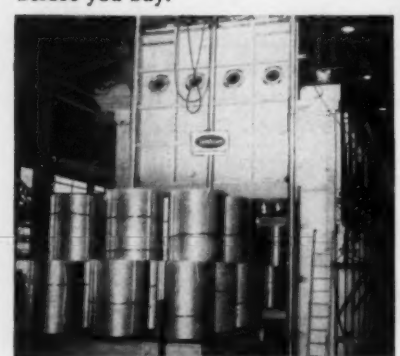

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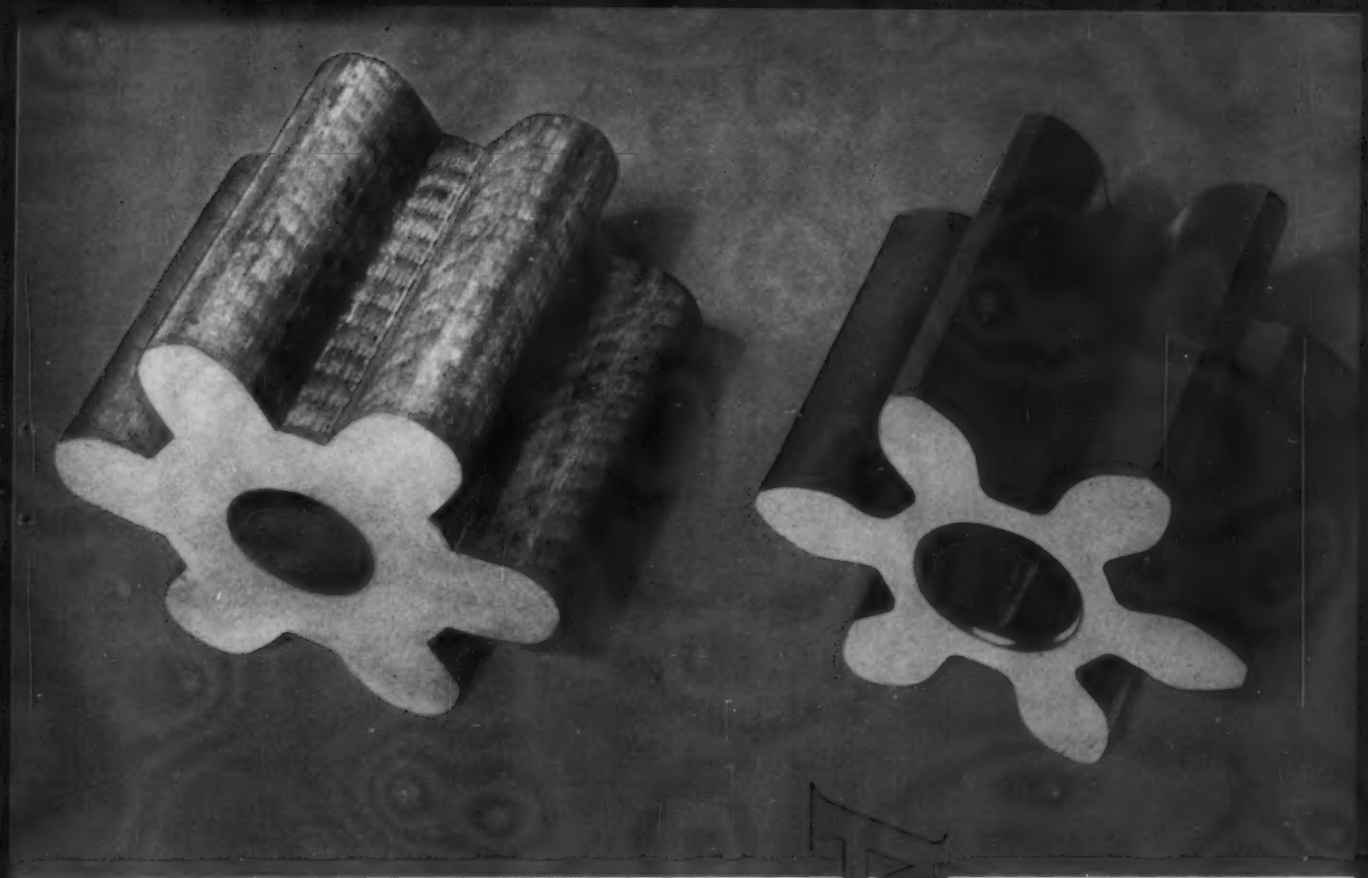
Circle 1198 on Page 48-B

Machining Titanium

Digest of "Use of CO_2 in Machining Titanium and Recovery of Titanium Chips", *Tsvetnie Metalli (Nonferrous Metals)*, No. 2, 1959.

In metal cutting a large amount of material is wasted as chips. Recovery of commercially pure titanium and titanium alloy chips is not efficient, since metal heats up during machining and hot chips are contaminated by contact with oxygen or burn up.

The Institute of Metallurgy of the Georgian Academy of Sciences has conducted studies of machining commercially pure titanium at temperatures below 0° C. (32° F.), using CO_2 as a coolant. Studies were made of the effects of machining speed, feed, and depth of cut upon heat generated and consequent oxidation. It was found that the cutting speed has the greatest influence upon the degree and rate of oxidation. The rate of feed and depth of



Note minimum clean-up necessary between casting of this 6-tooth pump impeller and finished part. (Illustrated parts are 4" in diameter.)

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Circle 1199 on Page 48-E

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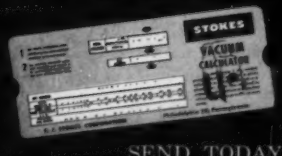

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Circle 1200 on Page 48-B

Machining . . .

cut, on the other hand, decrease the oxidation rate.

It was also found that the significant oxidation of titanium chips occurs at temperatures above 400° C. (750° F.) and, therefore, will occur at practical machining rates (without cooling).

Oxidation of chips was studied by weight measurement, comparison of temper color, and determination of reflectivity (irridescence). These studies showed that when a coolant is absent, increasing the cutting speed decreases reflectivity. This indicates extensive oxidation due to the increase in the cutting temperature. Increases in feed and depth of cut decrease oxidation rate, even though cutting temperature increases. When CO_2 cooling is used, titanium chips do not oxidize and are independent of the cutting cycle. Thus, the chips are not lost through burning or contamination.

Since oxidation of titanium is temperature dependent, and since the amount of heat evolved and the temperature of the cutting tool in cutting some titanium alloys are three to four times greater than for medium carbon steel, it is important to reduce the metal cutting temperature. This can be conveniently and inexpensively done by use of CO_2. In addition to reducing heat and protecting metal from oxidation, CO_2 improves machinability and increases tool life. Also, the uncontaminated titanium chips can be recovered and remelted.

ARTHUR B. TESMEN

Properties of Iodide Hafnium

Digest of "A Study of Some Mechanical, Physical, and Corrosion Properties of Iodide Hafnium", by J. G. Goodwin and F. R. Lorenz, *Nuclear Science and Engineering*, Vol. 6, 1959, p. 49-56.

CONTROL RODS for pressurized water reactors must have high neutron absorption, good corrosion resistance in high-temperature water, and adequate strength properties. At the time hafnium control rods were fabricated for the Shippingport Pressurized Water Reactor, only limited

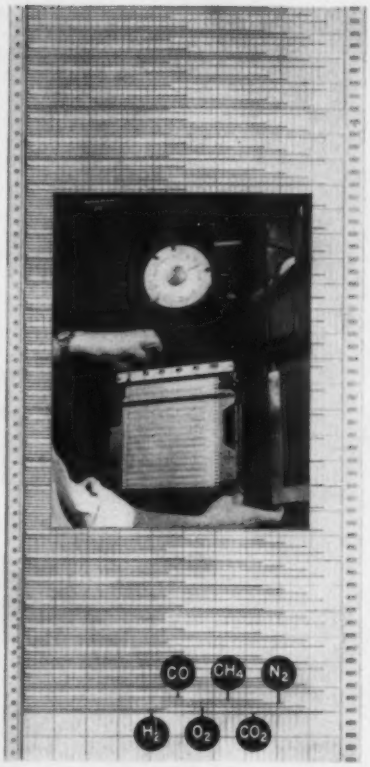

Chart record shows 6 components of furnace atmosphere measured cyclically by Furnace Gas Analyzer (inset).

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Circle 1201 on Page 48-B

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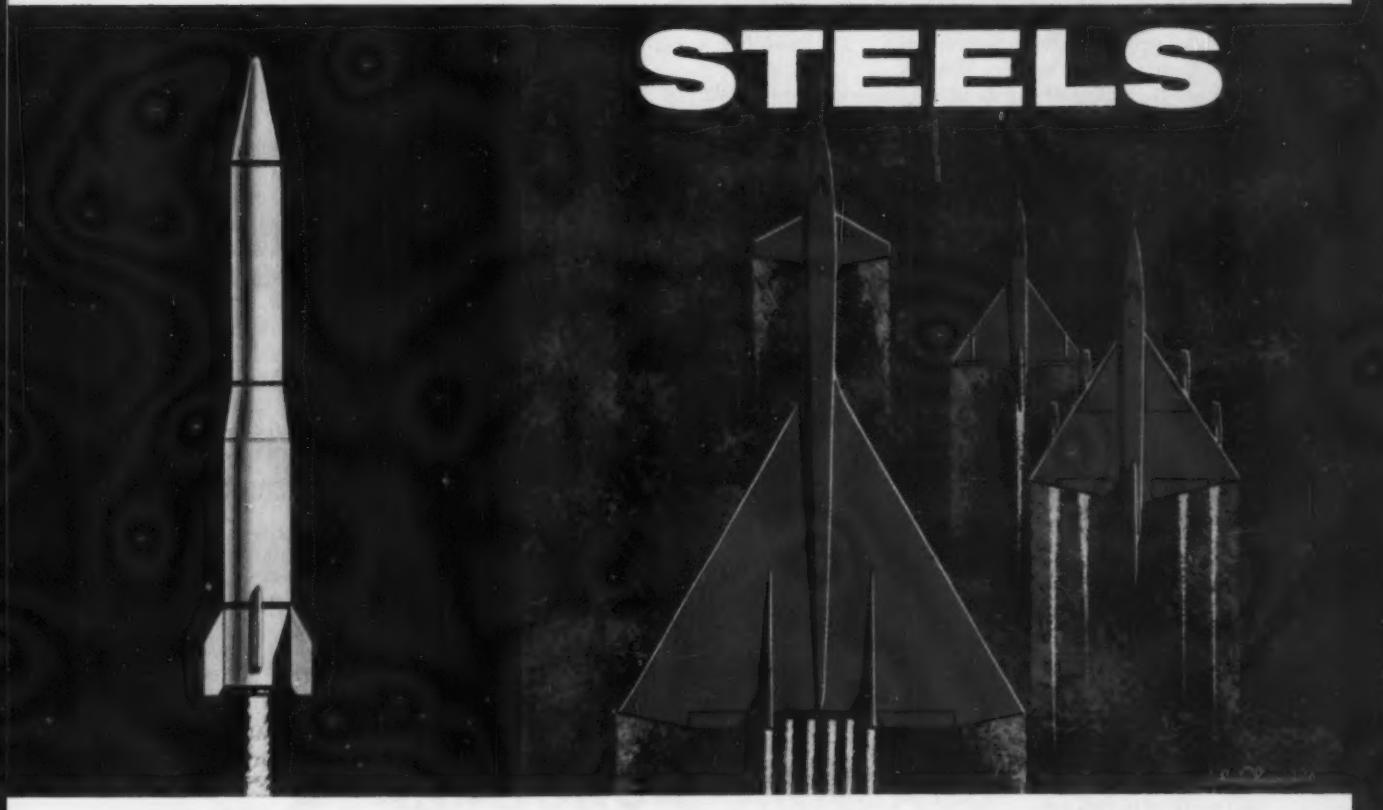

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12" square	22	10
9½" round	27	11
9" square	30	11
7" round	31	12
7" square	35	12

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Circle 1202 on Page 48-B

Hafnium . . .

data were available for the properties of hafnium (other than corrosion resistance). Since then, statistical studies have been performed on hafnium strip to determine properties.

Representative samples were taken from five different ingots of typical iodide hafnium. No significant differences in mechanical, physical, or corrosion properties were found which could be attributed to any differences in chemical analyses.

The average electrical resistivity varies essentially linearly from 56.62 ohms per circular mil-ft. at −196.0° C. to 498.02 ohms per circular mil-ft. at 351.2° C.

The yield strength (0.2% offset) decreases in a fairly linear manner from about 34,000 psi. at 80° F. to about 15,000 psi. at 700° F. The decrease in ultimate strength from about 64,000 psi. at 80° F. to about 33,000 psi. at 700° F. is also approximately linear although a given change in temperature appears to give somewhat greater decreases at the lower temperatures. The total elongation increases linearly from about 22% at 80° F. to about 43% at 700° F.

Hafnium appears to have measurable initial corrosion in 680° F. water (for 14 days) with little additional corrosion up to 250 days. Irradiation to a high flux reduces the average room-temperature impact strength to about one-half that of nonirradiated specimens. Temperatures of 300° to 500° F. remove the effects of irradiation on impact strength. The change in hardness due to irradiation corresponds to the change in hardness caused by a cold reduction of about 13%.

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Circle 1203 on Page 48-8

Scoring of Gears at High Temperature

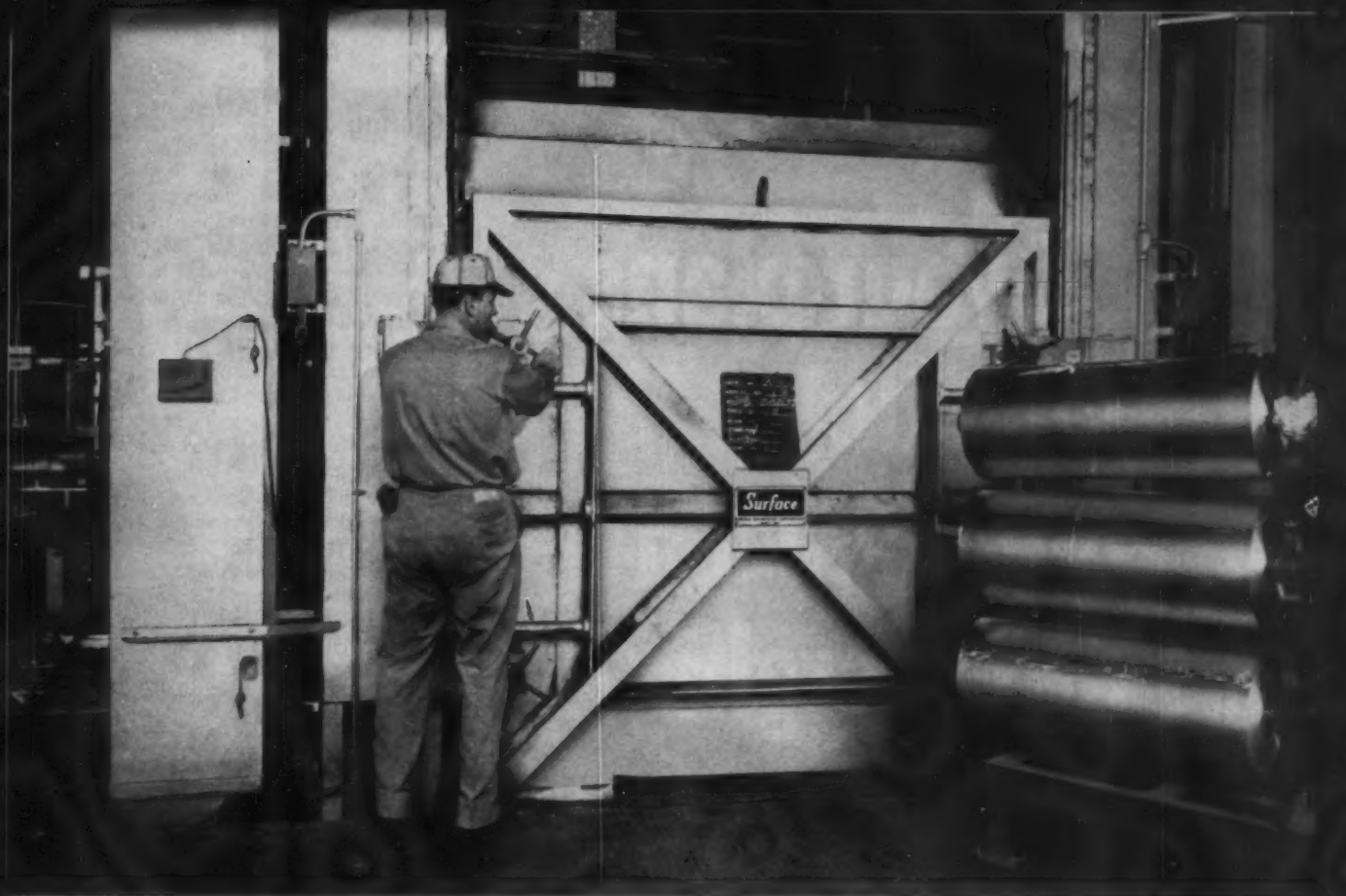
Digest of "Evaluation of Gear Materials Scoring at 700° F.", by E. G. Jackson, C. F. Muench and E. H. Scott. American Society of Lubrication Engineers paper No. 59 LC-6, presented at the A.S.L.E.-A.S.M.E. Lubrication Conference, New York, October 1959.

The main criterion of gear design has always been tooth breakage, but pitting and scoring are also important. As the speed increases, scoring becomes the limiting factor, and many failures in aircraft gears are initiated by this phenomenon. In connection with the development of high Mach number aircraft, a special gear roll test was used to evaluate the "compatibility" (or scoring resistance) of prospective gear materials at elevated temperatures.

The apparatus consists essentially of two 2.5-in. diameter rolls rubbing against each other. One has a constant speed of 175 rpm., while the other's speed can be varied up to 10,000 rpm. Contact width is ¼ in., and an oil jet is directed at the inlet wedge. Load is applied through the upper roll, the onset of scoring being detected by a squealing, screeching noise or a change in the signal from the load transducer, or both.

As an index of scoring resistance, a modification of the flash temperature parameter was used. This is essentially a function of the temperature, the speed and the load.

In the actual tests, the rolls were



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Circle 1204 on Page 48-8

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DESIGNERS AND MANUFACTURERS OF THE IMPACTER

Circle 1205 on Page 48-B

Scoring . . .

ground to the same surface finish (6 to 12 micro-in. rms.) and run in for 30 min. at room temperature to give a finish of 5 to 7 micro-in. The roll temperature was then raised to 600 to 700° F., the feed of the hot oil adjusted, and the machine brought to the test speed. Load, and if necessary, rubbing speed, was increased until scoring occurred and the test was stopped. A minimum of three test runs was conducted for each of the material-lubricant combinations.

The materials examined were M 50 high speed toolsteel, modified M 50 (0.15 to 20% C and 3.25% Ni), H-12 hot work die steel, M 1 high speed toolsteel, Matrix M 2 modified high-speed toolsteel, nitralloy N cobalt-chromium die steel, and 6 Al, 4 V titanium alloy. Various surface treatments were applied.

Two test oils were selected, one being typical of the silicone class (chlorophenyl methyl) and the other a high-temperature mineral oil (MLO 7056 A). The silicone oil was fed in at 600° F. while the mineral oil, being less stable, was fed in at 400° F.

The results suggested that hardness was the most important factor for the group of materials tested, although nitrided H-12 was definitely superior with silicone oil and only average with mineral oil. On the other hand, M 1 behaved much better with the mineral oil than with the silicone oil. With two exceptions, the surface hardnesses were in the range Rockwell C-55 to 60 at a temperature of 700° F.

The hardest surface was flame-plated tungsten carbide (Rockwell C-72) on the titanium alloy (Rockwell C-26). This material was quite unsatisfactory, the base metal apparently being too soft, even at 100° F., to support the 0.001-in. plate. Other soft cores supported case thicknesses in the range of 0.013 in. to 0.035 in.

Flash temperature parameters in most cases were higher with the mineral oil. It was also observed that whereas the whole rolling path was scored with the silicone oil, heavy circumferential scoring without spreading occurred with the mineral oil.

Necessarily the final choice of the optimum material – lubricant com-

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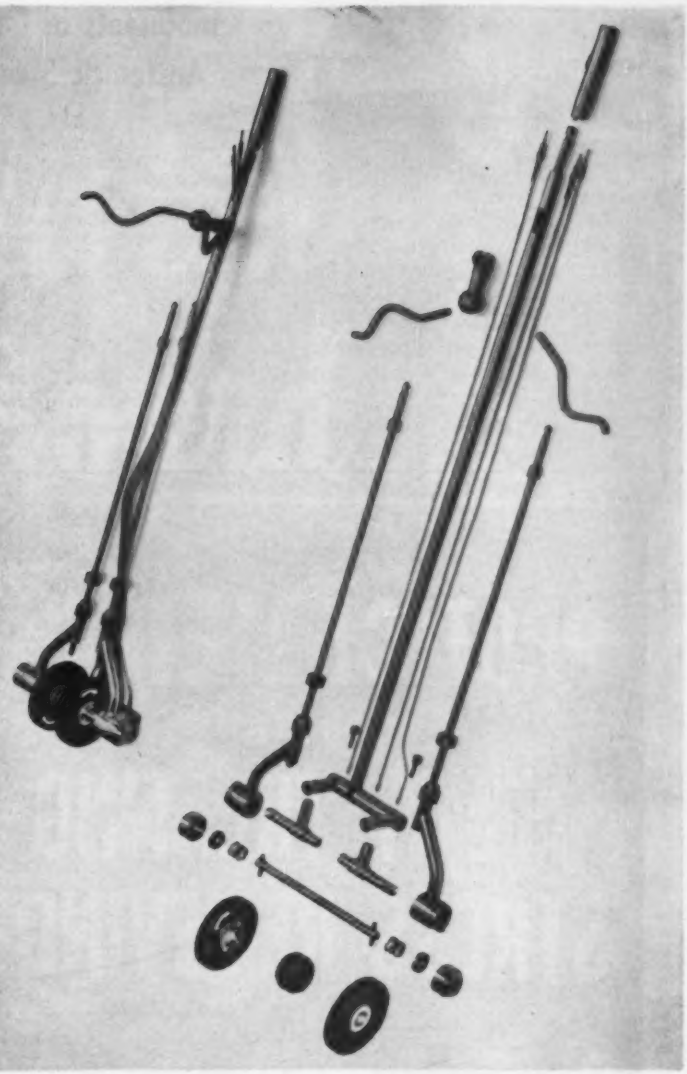

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Circle 1206 on Page 48-8

Scoring . . .

bination must include consideration of other factors, such as viscosity-temperature, oxidation and thermal stability requirements, as well as reaction effects with the material. For high-speed gears where scoring is the most probable operational limiting factor, however, it is recommended on the basis of the above tests that nitrided H-12 should be used with silicone oil, and M 2 with mineral oils.

R. C. A. THURSTON

Inoculants in Cast Austenitic Steel

Digest of "Effect of Inoculants on the Crystallization and Sulphur Distribution in Cast Austenitic Steel", by N. S. Kreshchanovskii and I. E. Zabludovskii, *Metallovedenie i Termich. Obrabotka Metallov*, March 1959, No. 3, p. 33-37; Brutcher Translation No. 4542.

INVESTIGATIONS ON THE high-temperature properties of 15% Cr, 25% Ni steels disclosed that higher sulphur contents have deleterious effects on toughness and on austenite stability. Hence, this study was made to determine the effects of cerium, calcium and zirconium additions on characteristics of cast austenite steels. Microscopic, macroscopic and autoradiographic techniques were used to determine grain sizes and sulphur distribution patterns. Radioactive sulphur additions were made to the melt because the usual types of sulphur printing are not suitable for austenitic steels.

The experimental heat, made in an acid electric furnace, contained about 0.04% S and was poured at 2830° F. Part of the sulphur was added as the radioisotope S^{35} in an amount corresponding to 1 microcurie per kg. of steel. This isotope has a half-life of 87.1 days. Four splits were poured from the heat using 55-lb. shank ladles. No addition was made to the first ladle; each of the others was treated with 0.2% Zr, 0.3% Ce or 0.5% Ca. After melting was completed, the steel was poured into sand molds to obtain test castings.

Macroetching and macroradiographs showed columnar grains at the surface and equiaxed crystals at the interior of the castings. As would be expected, the sulphur inclusions precipitated between the arms of the dendrites. The zirconium addition decreased the thickness of the columnar zone of crystallization and refined the size of the equiaxed grains. Calcium reduced the depth of the columnar crystallization to about 0.2 in. and also produced a fine grain size in the center of the castings. However, calcium had no effect on sulphur content. On the other hand, cerium lowered the sulphur level from 0.036 to 0.025% without affecting the grain structure. The sulphides tended to concentrate in the central part of the cerium-treated casting; they were uniformly distributed in the other castings.

Annealing the steels for 10 hr. at 2190° F. had no discernible effect on the sulphur distribution. Holding samples for 75 hr. at 2390° F., however, caused continuous chains of sulphide inclusions to form in the grain boundaries of all but the cerium-treated steel.

The authors recommend adding cerium and calcium simultaneously to austenitic steels to secure desulphurization and a uniform sulphur distribution. F. W. BOULGER

(More digests on p. 190)

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Circle 1207 on Page 48-B

Metal Progress

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AZ81
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Circle 1 on Page 48-A

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Circle 2 on Page 48-A

Need Help Designing That Aluminum Extrusion?

TEAM UP with JARL

THERE'S A WORLD OF DIFFERENCE

The *difference* starts the moment you meet the Jarl salesman. He's an engineer . . . well qualified to make on-the-spot recommendations in designs. Team up with Jarl and you'll get the right shapes made to most exacting design specifications. You'll be sure of close die control . . . quality safeguards every step . . . on-time deliveries. Send for our stock die catalog or send rough sketches for assistance with your design.

ANODIZING
JARL EXTRUSIONS, INC.
Dept. MP, Linden Ave. • East Rochester, N. Y.

Circle 3 on Page 48-A

LA-CO
Aluminum Soldering Flux
Now . . . Solder Aluminum with ordinary soft solders

- Use 60-40, 50-50, 40-60, 95-5 solders
- No new soldering techniques
- Non-acid . . . Self-cleaning

A major breakthrough in aluminum fabrication. Use ordinary soft solders . . . ordinary irons or torches. Remarkable fluxing action achieves perfect bond of aluminum and solder making possible the fabrication of aluminum to aluminum, copper, steel, stainless steel, galvanized iron, brass, etc.

Write for sample, or engineering help on any fluxing problem.

LA-CO BRAND
LAKE Chemical Co.
3079 W. Carroll Ave., Chicago 12, Ill.

LA-CO
Silver Solder Flux
Greater speed and economy for all silver soldering!

- Packed in tins
- Will not harden
- Non-acid . . . Self-cleaning

For all silver soldering in 1125° to 1700° F. heat range. Dissolves all refractory and non-refractory oxides . . . solder penetrates completely into all areas, for maximum strength without solder waste. Completely acid-free—will not pit or stain metals. Always-ready paste form . . . will not harden or crystallize.

Write for sample, or engineering help on any fluxing problem.

LA-CO BRAND
LAKE Chemical Co.
3079 W. Carroll Ave., Chicago 12, Ill.

LA-CO
Stainless Steel & Chrome Soldering Flux
Safer . . . Surer . . . Cleaner

- Doesn't stain
- Non-acid
- Self-cleaning

For soldering all stainless steel and chrome, including 300-400 Series, with ordinary soft solders. Requires no pre-cleaning. Acid-free formulation will not pit metals, leaves no stains. No buckling on even light gauge work. In liquid or paste form.

Write for sample, or engineering help on any fluxing problem.

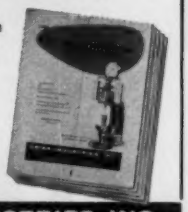
LA-CO BRAND
LAKE Chemical Co.
3079 W. Carroll Ave., Chicago 12, Ill.

Circle 4 on Page 48-A

the GENUINE BRINELL

HARDNESS TESTING MACHINES made by the Alpha Co. of Sweden and available from our stock at New Rochelle

Never approached in ACCURACY AND CONSTANCY of calibration . . . at the standard 3000kg test load . . . maximum error plus or minus 2½ kg



Write for Bulletin No. A-18

GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N. Y.

Circle 5 on Page 48-A

FIND CRACKS QUICK!

QUICK TEST ENDS VISUAL GUESSWORK!

SPOTCHECK finds cracks, porosity, and leaks you can't see (any defect open to the surface). SPOTCHECK—marks them with a brilliant red warning. Users report speedy, money-saving results. SPOTCHECK is used to inspect metals, carbides, ceramics, plastics, etc. Multi-use SPOTCHECK can simplify your maintenance and in-progress inspections. SPOTCHECK'S complete SK-3 kit is portable; no other equipment needed!

Spotcheck offers

- NEW! NONFLAMMABLE
- PUSH-BUTTON EASE
- FLEXIBILITY . . . Use on tools, parts, machinery, etc.
- LOWEST COST Dye Penetrant materials — pressure canned or bulk. Why use higher priced substitutes?

COMPLETE SK-3 KIT ONLY
$36.00 U.S.A. only
Plus $1 for packing and shipping

CALL YOUR DISTRIBUTOR or Mail Check or P. O. with Coupon Today!

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☐ Please send____SK-3 kits @ $36.00 each plus $1.00 each packing and shipping.
☐ Send FREE bulletin only. Includes low SPOTCHECK material prices.

Name_____Title_____
Company_____
Address_____
City_____Zone____State_____

Circle 6 on Page 48-A

Solve Inspection Sorting Demagnetizing Problems with MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed — 120 ft. per minute.

MULTI & SINGLE FREQUENCY EQUIPMENT

Eddy current equipment for non-destructive testing of non-magnetic metal tubing, bars, wire, ⅛" to 3" dia. at test speeds from 200 to 600 fpm. Multi-frequency unit offers 6 simultaneous inspection methods to indicate surface and subsurface flaws, or variations in mechanical, physical, and metallurgical properties. The single frequency unit offers one inspection method to indicate flaws only.

WIRE ROPE EQUIPMENT

Electronic equipment for inspecting ferro-magnetic wire ropes from 1/32" to 3" diameter. Detects broken, cross-over or missing wires, plus defective welds and deformations at production speeds up to several hundred feet per minute.

COMPARATORS AND METAL TESTERS

Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

DEMAGNETIZERS

Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

"THE TEST TELLS"

For Details Write:

MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

Circle 7 on Page 48-A

Rockwell-scaled
HARDNESS TESTER

pat. app. for

REVOLUTIONARY— NEW-"ON-THE-JOB" *Precision Instrument*

only $39.50 *complete!*

A steel ball of exact weight and hardness is dropped from an exact height, insuring a precise reading in Rockwell C scale. Ideal for spot or production checking. Portable, easy to read . . . rugged and dependable. In use in many large plants and shops.

Order yours today at this low price. Satisfaction guaranteed.

DETROIT HARDNESS TESTER
17644 Mt. Elliott Ave.
Detroit 12, Mich.

Circle 8 on Page 48-A

SCHENCK

Multi-Purpose Fatigue Testing Machines for Research and Production

push-pull, bending, torsion tests, on hard and soft materials. Infinitely variable speed—extremely large stroke—additional low speed drive.

Built-in controls maintain constant static and dynamic load.

Model PV— Vertical, 0.6—20 tons load, 5/16" to 5/8" stroke (45) 600—8000 cPM

Model PB— Horizontal, 3—100 tons load, 1" to 2" stroke (30) 280—4500 cPM

Accessories for environmental tests available.

Write for information.

COSA CORPORATION
405 Lexington Avenue, New York 17, N. Y.

Circle 9 on Page 48-A

HARDNESS TESTING
SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.

Circle 10 on Page 48-A

TENSILKUT

Pat. Pend., U.S., Canada

● Now with TENSILKUT, whatever your testing methods or materials, you can have perfect precision machined physical test specimens in less than two minutes.

● TENSILKUT precision machines all foil, film, sheet and plate metals . . . from .0005" foil to .500" plate. Hard .001 stainless steel foil to soft ½" aluminum, soft plastic film 1 mil in thickness or the abrasive glass laminates in .500" plate, are machined with specimen configurations accurate to ± .0005". Machined edges are completely free of cold working or heat distortion and require no hand finishing.

● TENSILKUT table and floor models are available with motors from ½ to 2½ h.p. Write for free brochure.

SIEBURG INDUSTRIES INCORPORATED
Danbury Industrial Park, Danbury, Connecticut

Circle 11 on Page 48-A

REVCO

ULTRA-LOW TEMPERATURE CABINETS

for
- Research
- Storage
- Seasoning
- Testing

Seven styles...chest capacities from 1.5 to 6 cu. ft. Uprights up to 22 cu. ft. Temperatures to —140° are controllable within 1°. Immediate delivery.

For FREE folder, "Selecting a Low Temperature Cabinet," write Revco, Dept. MP-70.

Industrial Products Div.
REVCO INC.

Circle 12 on Page 48-A

- CLAMPS, JAWS & BASE PLATE ARE ELIMINATED
- NO CONVERSIONS OR CALCULATIONS
- TEST ANY SIZE, SHAPE OR TYPE METAL
- NO SKILL REQUIRED
- SCALE READINGS IN ROCKWELL & BRINELL
- ACCURACY GUARANTEED

Many thousands used by industry and government. Write, wire or call for additional details and prices.

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TUrner 4-6696 Dept. MP

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They Can't Give US the HOTFOOT

for we produce

HEAT RESISTANT

PATENT PENDING

OROTHERM HT

24Kt Acid Bright GOLD

WRITE, WIRE, PHONE OR TWX FOR COMPLETE INFORMATION

ST1-6100

Technic Inc

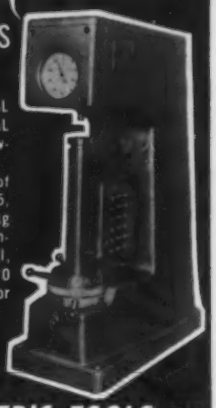
PRODUCTS OF RESEARCH

P.O.Box 965
Providence 1 R. I.

Chicago Office
7001 North Clark Street

Circle 14 on Page 48-A

Frank NEW DUPLEX HARDNESS TESTER

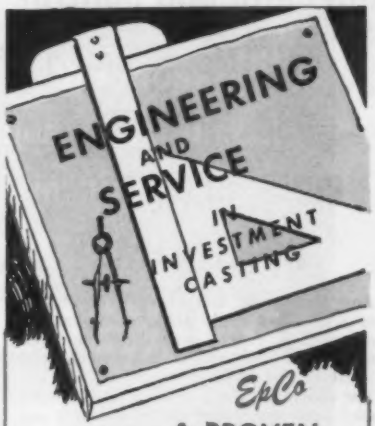


for all NORMAL AND SUPERFICIAL Tests in ONE low-priced machine. 6 Major loads of 150, 100, 60, 45, 30 and 15 kg available by push-button control, plus selective 10 and 3 kg minor loads.

Request Circular #506

OPTO-METRIC TOOLS, INC.
137 M P VARICK STREET, NEW YORK 13.

Circle 46 on Page 48-A



EpCo

A PROVEN DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING
Special Feature —Nickel content held to 35% minimum — 36% maximum

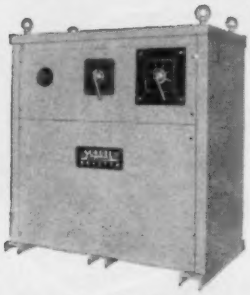
STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.

ENGINEERED PRECISION CASTING CO.

MORGANVILLE, N. J.

Circle 15 on Page 48-A

SORGEL
Saturable Reactors



Saturable Reactor
with tap changing transformer

Regulate and control electric ovens and furnaces more accurately and efficiently

Any amount of A.C. power from 1 Kva to 3000 Kva, single phase or 3-phase, at any voltage, can be controlled, regulated, and varied in stepless increments, with SORGEL Saturable Reactors.
The control can be a small manually operated hand wheel that can be placed in any desired location, or it can be automatically controlled, regulated and varied by a thermostat or any other instrument or device.
SORGEL reactors are designed to meet your exact requirements. Let us know what your problems and requirements are, and we will submit our recommendations with complete information.

Write for Bulletin 658.

●

Also a complete line of dry-type transformers.

All standard and intermediate ratings, ¼ Kva to 10,000 Kva, 120 to 15,000 volts.

●

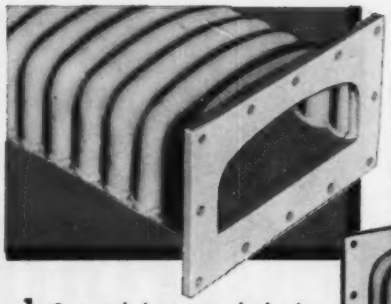
Sales Engineers in principal cities

Consult the classified section of your telephone directory, under the heading "Transformers," or communicate with our factory.

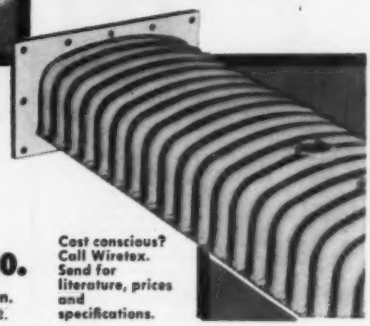
Sorgel Electric Company

834 W. National Ave., Milwaukee 4, Wis.
Since 1916 devoted to creative engineering and manufacturing craftsmanship

Circle 16 on Page 48-A



Wiretex corrugated muffles
...last longer, lower costs!



1 Custom design at standard prices.
2 Warping reduced to a minimum.
3 Arc, heli-arc or electric welding.
4 Choice of sizes, alloys, styles.
5 Prompt delivery.

Wiretex mfg. co.
5 Mason St., Bridgeport 5, Conn.
Specialists in Processing Carriers Since 1932.

Cost conscious? Call Wiretex. Send for literature, prices and specifications.

Circle 24 on Page 48-A

Now find cracks, leaks, defects
... quickly, easily!

ZYGLO
BLACK LIGHT Portable Inspection Kit

Easy to Use • in the shop • in the field

FLUORESCENT PENETRANT INSPECTION

"IDEAL FOR"
- Low-volume production testing
- Maintenance and tool inspection
- Reliable leak test —welded tanks

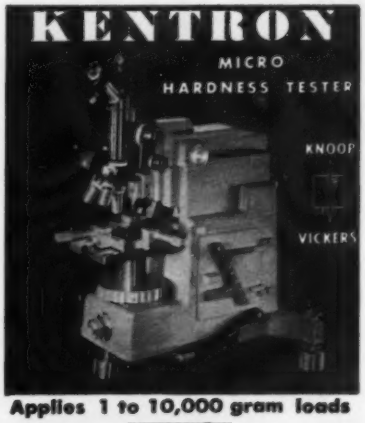
FIRE SAFE
New, improved high flash-point materials. Packed in push-button spray cans.

Genuine ZYGLO KIT complete with 100 W. BLACK LIGHT
$125.00
F.O.B. Chicago

MAGNAFLUX CORPORATION
7328 West Ainslie Avenue
Chicago 31, Illinois

Circle 18 on Page 48-A

KENTRON
MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads
Write for Bulletin

Kent Cliff Laboratories Div.
The Torsion Balance Company
CLIFTON NEW JERSEY

Circle 19 on Page 48-A

MORE THAN 50,000
METALLOGRAPHIC SAMPLES POLISHED DAILY WITH
DISA-ELECTROPOL

EXCLUSIVE "DISA" FEATURES
- Quick and convenient exchange of electrolytes
- "On the spot" polishing of large objects by "Movipol" attachment
- Components for external etching with every "Disa"

For complete information on this and other metallographic specimen preparation apparatus write or phone

WILLIAM J. HACKER & CO., INC.
P.O. Box 646, W. Caldwell, N.J. Tel. Capital 6-8480

Circle 17 on Page 48-A

IDENTIFY PARTS FOR HEAT TREATING!

Markal PAINTSTIK MARKERS "M" and "M-10"

Mark any parts while cold, identify them after heat treating regardless of temperatures and oil or water quenchings. Use "M" up to 1600° F., "M-10" up to 2400° F.

WRITE ON LETTERHEAD FOR complete Paintstik information.

MARKAL COMPANY
3118 West Carroll Ave. Chicago 12, Ill.

Circle 48 on Page 48-A

STOP CARBURIZING, DECARBURIZING, SCALING DURING HEAT TREATMENT!

Markal "C-R" COATINGS

MARKAL "C-R" COATINGS will protect a wide range of metals at temperatures up to 2100° F. against carburizing, corrosion, scaling and the like. Coatings are easily applied, easily removed after treating.

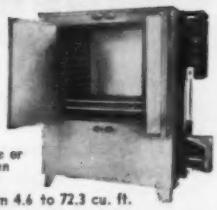
WRITE ON LETTERHEAD FOR complete Coating information.

MARKAL COMPANY 3118 West Carroll Avenue • Chicago 12, Illinois

Circle 49 on Page 48-A

UNIFORM HEAT
throughout the work space

30 STANDARD CABINET MODELS



Model HB Electric or Gas Cabinet Oven

- Work space from 4.6 to 72.3 cu. ft.
- Temp. ranges from 100 to 1250° F.
- Electronic combustion devices for gas models
- Indicating control instrument
- Factory tested

Other ovens from $121.50 up; laboratory, bench, walk-in and custom built models.

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Specialists in Heat Process Equipment

GRIEVE-HENDRY CO. Inc.
1339 N. Elston Ave. Chicago 22, Ill.

Circle 21 on Page 48-A

FREE the most valuable technical information ever prepared on FLAME HARDENING

DETROIT flame hardening co.
17644 Mt. Elliott Ave. • Detroit 12, Mich. • TWinbrook 1-2936

Limited supply available—write for your copy now and be assured of receiving this booklet

Circle 23 on Page 48-A

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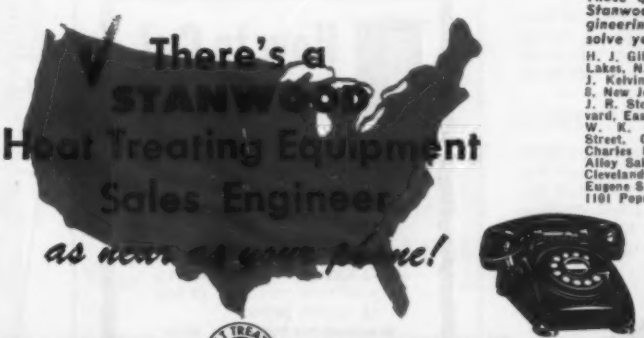
Fred E. Blair, Blair Engineering Co., 4100 Grape St., Denver 16, Colo.
Richard D. Lindner, 583 Wolcott Hill Rd., Wethersfield, Conn.
J. R. Stewart, 2400 W. Broward Blvd., Ft. Lauderdale, Fla.
Logan J. Swinehart, 309 St. Louis Avenue, Rockford, Illinois.
William McAtee, 626 N. DeQuincy St., Indianapolis 1, Indiana.
Harry I. Dixon, Metallurgical Products Co., 1199 Beacon St., Brookline 46, Mass.
Carl H. Schmidt Co., 16405 W. 8 Mile Rd., Detroit 35, Mich.
A. A. Gustafson, 161 Griggs — Midway Bldg., Fairview at University, St. Paul 4, Minnesota.
The Shea-Brownell Co., 3903 Olive Street, St. Louis 8, Missouri.



These qualified representatives plus Stanwood's broad experience, engineering and modern facilities can solve your problems.

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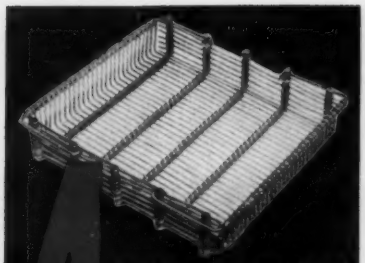
J. Kelvin Stahl, 716 River Road, Trenton 8, New Jersey.
J. R. Stewart Co., Inc., 2900 Erie Boulevard, East Syracuse 3, New York.
W. K. Hile Company, 1236 Morehead Street, Charlotte 7, N.C.
Charles Plant Jr. and Warren B. Lum, Alloy Sales & Service, 8905 Lake Avenue, Cleveland 2, Ohio.
Eugene S. Craig, Craig Indust. Equip. Co., 1101 Popular Ave., Memphis 4, Tennessee.
Gipson Supply Co., 122 Grant Ave., Pittsburgh 9, Pa.
M. K. Griggs Co., Inc., 5523 Dyer St., Dallas 6, Texas. 2801 San Jacinto, Houston 4, Texas.
Robert M. Onan Co., 5138 North 38th St., Milwaukee 9, Wisconsin.

STANWOOD CORPORATION
4817 W. CORTLAND STREET CHICAGO 39, ILLINOIS

Circle 22 on Page 48-A

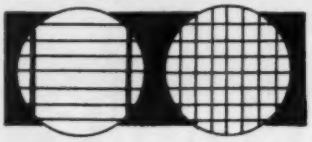


4 MORE REASONS YOU SHOULD TRY . . .

bixco FABRICATED HEAT-TREAT BASKETS

1 MORE OPEN AREA

Our unique looped wire liner (with slotted openings) affords 30% to 100% greater open area than conventional liners. Faster heats, greater circulation of atmospheres and more uniform quenches are a direct result.



bixco BUILT-IN Looped Wire Liner

Conventional Liner

2 LESS WEIGHT

In the Economy 6 Series with built-in liner and round rod framing, total basket weight is kept to an absolute minimum without sacrificing high strength.

3 TRUE ECONOMY

Our many exclusive features bring basket maintenance and furnace operating costs DOWN. Bixco baskets perform better because they are made better.

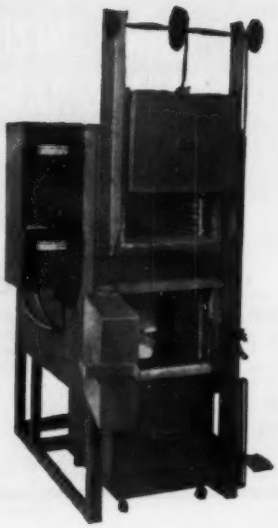
4 SPACE AGE ENGINEERING

Meeting the demands for better baskets is a Bix Company specialty. Besides fabricating in all standard metals we also produce baskets of Molybdenum. Special designs and applications are available on request.

For complete information write:

bix COMPANY
FAIRGROUNDS ROAD
WELLINGTON, OHIO

Circle 25 on Page 48-A



LUCIFER "SPACE-SAVER" COMBINATION HEAT TREATING FURNACES

Two series (8012 and 8008) of "space-saver" combination heat treating furnaces are produced by Lucifer Furnaces, Inc. Hardening, drawing or preheating, and quenching operations can be performed with one furnace. Each furnace has separate controls permitting independent operation of each unit. The 8012 series chambers operate at 2300, 2000 and 1250° F.; while the 8008 series chambers reach 2300, 2000, and 800° F. The furnaces operate on standard line voltage . . . no transformer necessary. Twenty standard low-cost models are available and each is a complete unit . . . just connect to power supply.

For information about the "space-savers", our complete line, or free engineering advice, call on . . .

LUCIFER FURNACES, INC.
Neshaminy 7, Pennsylvania
Diamond 3-0411

Circle 26 on Page 48-A

How to Cut Pot Costs:

Buy low-cost Eclipse pressed (not welded) steel pots . . . and replace them on a regular schedule.

1 Lower initial cost
2 Elimination of failures
3 Faster, more even heating
4 Quantity discounts earned on your total purchases in any 12 month period.

Guaranteed free from defects. Write:
Eclipse Fuel Engineering Company
Industrial Combustion Division
1127 Buchanan St., Rockford, Ill.

Eclipse PRESSED STEEL POTS

Circle 27 on Page 48-A

BRAND NEW FURNACES AT USED PRICES!

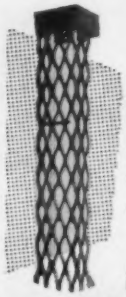
	WIDE	LONG	HIGH	TEMP	KW
Car Type	5'	10'	5'	1250° F.	120
Roller Hearth	2'	20'	1'	2100	120
Roller Hearth	4'	18'	2'	1200	GAS
Roller Hearth	4'	45'	2'	1400	GAS
Roller Hearth	4'	34'	1'	2050	180
Roller Hearth	5'	42'	4'	1500	GAS
Pusher	12"	110"	8"	2000	60
Drever Pusher	14"	120"	7"	2100	120
Harper Pusher	17"	14'	7"	2500	150
West. Pusher	18"	15'	8"	2600	179
Lindberg L. Pusher	15"	30"	12"	2500	80
Ipsen Pusher	24"	36"	18"	1750	GAS
Furnace Eng. Pusher	63"	30'	46"	1800	GAS

ALSO ALL TYPES OF FURNACE ACCESSORIES, PYROMETERS, AND LAB EQUIPMENT. WIRE OR CALL COLLECT!

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

Circle 28 on Page 48-A

there's a *Glo*-QUARTZ* IMMERSION HEATER for Your Every Heating Requirement



- INSTANT HEATING
- SHOCK-PROOF
- AVAILABLE IN ALL VOLTAGES —WATTAGES, ONE AND THREE PHASE

Available from your Electroplating Distributor

WRITE FOR BULLETIN ▶

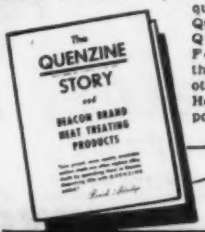
Glo-QUARTZ
ELECTRIC HEATER CO., INC., Willoughby, Ohio
*Reg. U. S. Pat. Off. Phone: Willoughby 2-5521

Circle 29 on Page 48-A

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



ALDRIDGE INDUSTRIAL OILS, Inc.
3401 W. 140th St., Cleveland 11, Ohio

Circle 29 on Page 48-A

$99.95 only

Net pint size

Powerful 40 watt output
Stainless steel tank

Full ½ gal. capacity

DISONTEGRATOR® SYSTEM FORTY
ULTRASONIC CLEANER

The lowest priced ultrasonic cleaner ever sold!

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320	320	5	14 x 10 x 9	349.95
520	520	10	20 x 10 x 10	999.95
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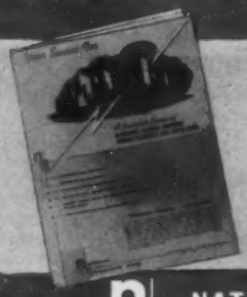
Circle 32 on Page 48-A

FREE! ULTRASONIC CLEANING BULLETIN



Describes National Ultrasonic Corporation's:

- Applications Laboratory service. Your sample parts are cleaned ultrasonically and equipment and cost recommendations are made at no charge.
- STANDARDLINE medium power cleaners for all applications requiring average energy levels.
- HEAVYDUTYLINE high power cleaners for industrial applications requiring high energy density.
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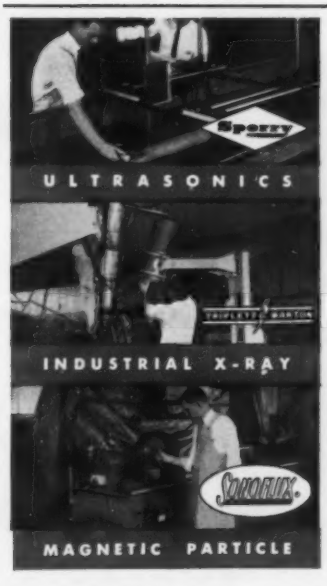

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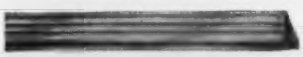

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We'll give you quick delivery on small orders as well as big orders. We'll help you keep your production schedule.

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Eliminates RUST & Fire Hazards Non-Flammable Non-Toxic

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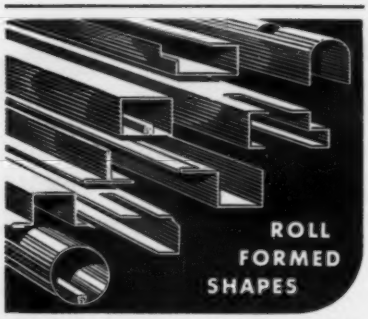

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MARTINDALE

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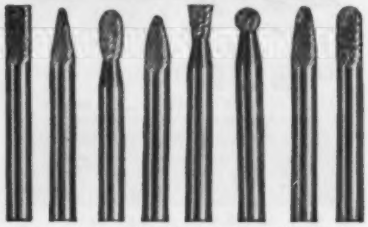

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MARTINDALE ELECTRIC CO.

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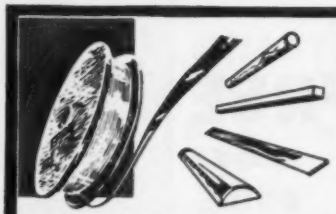

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Combination Models—Series H and D

Hardening Range ..... 2000° F and 2300° F
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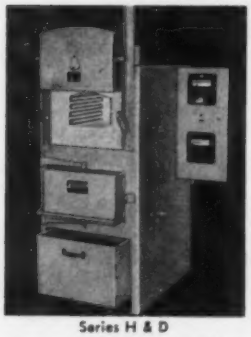
Four Standard Models ..... or special design to suit



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General Purpose Box Models
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Ten models 2000° F and 2300° F range

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Inquiries are invited—no obligation
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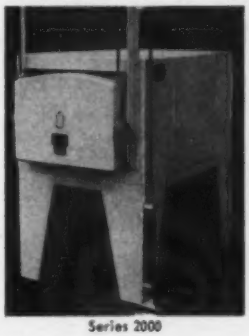

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Star Stainless screws have clean—bright—shiny—heads

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- Every Wilson "Brale" Diamond Penetrator is identical in angle and radius.
- Only flawless diamonds, free from cracks or chips, are used.
- Microscopic inspection and a comparator test of each diamond assures consistent quality.
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- Special penetrators available for testing unusual areas.

Write for Catalog RT-58 for details on Wilson "Brale" Penetrators plus the complete line of Wilson Rockwell hardness testers.

WILSON "ROCKWELL" HARDNESS TESTERS

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ACCO

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Circle 1208 on Page 48-S

Mechanically Polished Surfaces

Digest of "The Nature of Mechanically Polished Surfaces", by L. E. Samuels. Paper presented at the Golden Jubilee Convention, American Electroplating Society, June 1959, Detroit.

A COMMON CONCEPT of mechanical polishing is that it occurs by flowing or smearing of material across the surface with the flowed material filling in depressions and thereby flattening the surface. The available evidence, however, indicates that polishing (whether metallographic, industrial, or abrading) occurs by a cutting mechanism. The polished surface is always crystalline but is deformed. The flow theory suggests movement of material from one point to another with little, if any, removal from the surface. Actually, material is removed at significant rates during polishing with continuous removal at a fairly constant rate as long as polishing is continued. The difference between various finishes is basically one of degree. The more highly polished a surface, the finer the surface scratches, the smaller the magnitude of surface misorientation, and the thinner the deformed layer.

A cutting mechanism suggests plastic shearing of surface layers in the direction of cutting. There is evidence of such shearing, but it is not nearly large enough to account for closure of exposed cavities. If polishing is done properly, the evidence indicates that closure comes from compressive collapsing of the entire cavity. Surface shearing may be more important when heavy pressures, loaded wheels, or worn abrasives are used. Further systematic investigation is needed.

The deformed surface layer appears to have three zones. The first and outermost zone follows the profile imposed by the surface scratches, and extends beneath the root of the scratches about as far as the scratch is deep. The second zone is composed of rays extending from individual scratches in which there are indications of lamellar slip bands. The third zone is a lightly deformed region between the rays and extends for a considerable depth beneath them.

Presumably the only zone of importance is the outermost one produced by the final stage of preparation for electrodeposition. Examination indicates this zone is broken up into small coherent crystalline fragments which are frequently rotated in a completely random manner at the extreme surface. The plastic strain decreases rapidly with depth beneath the surface. Plastic strain, at all depths, decreases considerably with increasing fineness of polish.

One definite effect of surface deformation is the initiation of growth of a deposit of fine randomly oriented crystallites in instances where a coarse-grained continuous deposit would otherwise grow. This occurs with a surface layer of considerable depth which is not likely to be removed by a normal preplating etch. There is some evidence that the deformed layer itself adversely affects the over-all adhesion of an electrodeposit. This needs further investigation.

C. O. SMITH

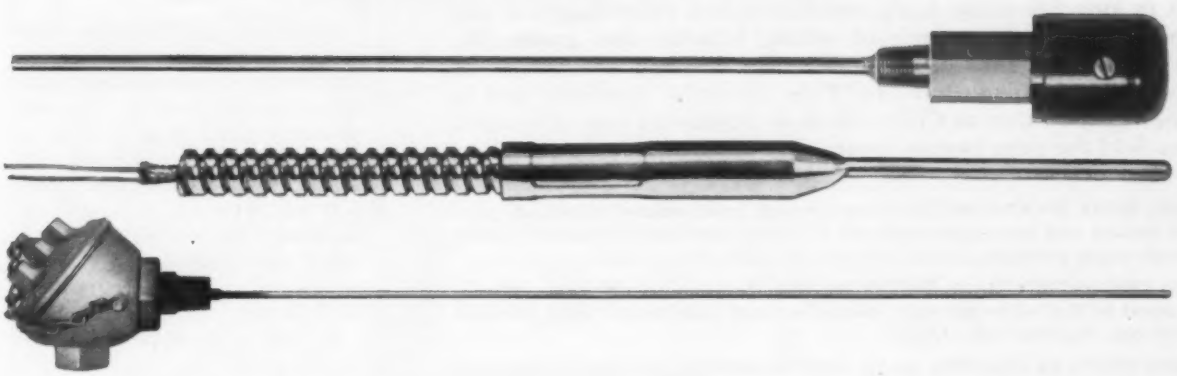
Yttrium Alloys

Digest of "Yttrium and Its Alloys", *Tsvetnie Metalli (Non-Ferrous Metals)*, No. 1, 1959.

PRODUCTION OF METALLIC YTTRIUM is of recent origin, and, therefore, the amount of published data on its properties is relatively small. Metallic yttrium has a silvery appearance, which turns to a greyish oxide upon long air exposure. Judging from the fracture appearance, 94 to 96% pure technical yttrium has a coarse grain structure similar in appearance to cermets.

Its density is 45 g. per c.c. (1.63 lb. per cu. in.); it is thus less dense than other rare earths. Its position in the periodic table indicates that it should form stable chemical combinations with the light metalloids such as boron, carbon, nitrogen and oxygen. Its microstructure consists of large grey grains of the base metal with the light etching secondary phase of the eutectic type. The latter appear to be the oxides of rare earth elements and metallurgically insoluble impurities. Melting point of 96.5% pure metal was found to be 1500° C. ± 20° (2730° F. ± 40). While analyses of tested

CHOOSE FROM 150,000 STANDARD *MegopaK* SMALL-DIAMETER THERMOCOUPLES



If you've been looking for small-diameter, flexible thermocouples with high speed of response, search no more. You'll find exactly what you need in Honeywell's *MegopaK** line.

MegopaK is a combination of thermocouple wires, mineral insulation and a protecting sheath, compacted into a solid mass with a diameter as small as 1/16". You can get *MegopaK* in standard lengths up to 25 feet, and in lengths up to 50 feet on special order. They're available with copper-constantan, iron-constantan and *Chromel-Alumel*** calibration. In all, there are more than 150,000 standard combinations of materials and fittings. These top-quality thermocouples are supplied in bulk, and as elements with wires welded into a measuring junction, or as complete assemblies.

MegopaK assemblies come complete with terminations (heads, plugs, etc.) and mounting attachments. Also available are special configurations, tests, material and calibration certifications.

MegopaK thermocouples and other pyrometer supplies are stocked at our Los Angeles and Dallas depots as well as in Philadelphia to give you the fastest possible service anywhere in the country.

Check with your nearby Honeywell field engineer for complete details, or write for Catalog G100-4.

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H HONEYWELL First in Control SINCE 1885

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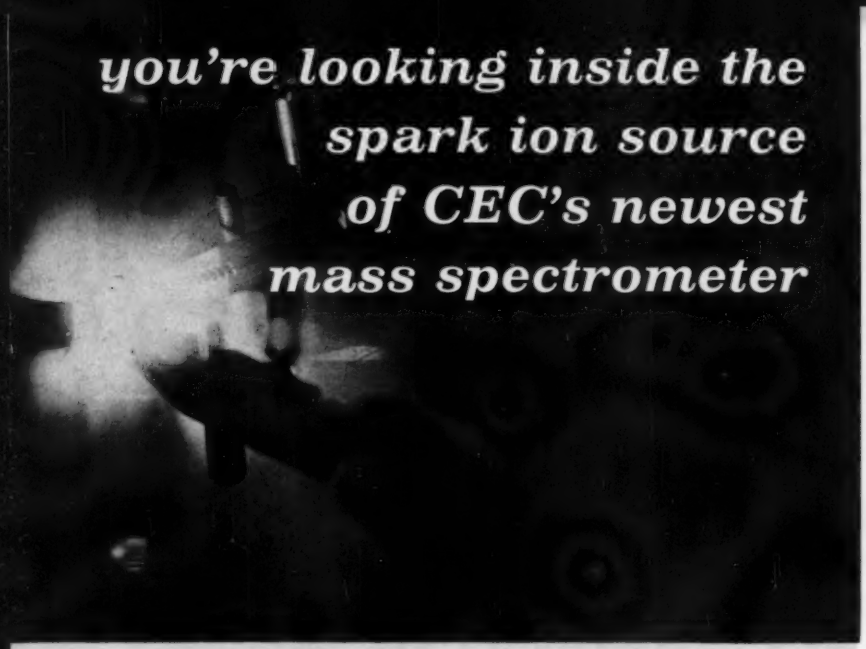

you're looking inside the spark ion source of CEC's newest mass spectrometer

Here's where metals, semi-conductors and other solids are ionized for analysis by the solids model of CEC's new 21-110 Series Mass Spectrometer.

First to provide ultra-high resolution and versatility for advanced materials research of solids, liquids, and gases, the 21-110 distinguishes mass differences beyond the range of standard mass spectrometers. This powerful research tool is the newest addition to CEC's mass spectrometer line—foremost in the field for over twenty years. Included in today's complete line are:

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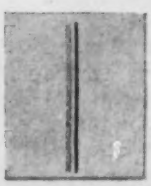
Actual photo-plate record from the 21-110 shows three mass spectral lines resolved at m/e 28. The two closest lines represent ions of CO and N_2 which differ by only 0.01123 mass units.

Circle 1210 on Page 48-B



21-110 Series provides a selection of modular ion sources and ion detectors for different applications. Conversions can be made easily by operator. Bulletin CEC 21110-X1.

Analytical & Control Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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Yttrium . . .

material showed a thermal effect at 680 to 700° C. (1260 to 1290° F.), it was attributed to the presence of lanthanum and cerium, rather than to polymorphism.

Mechanical Properties

The ultimate tensile strength of yttrium was found to be 16 kg. per sq. mm. (22,750 psi.) and elongation and reduction in area were not found. Its compressive strength was found to be 82 kg. per sq. mm. (116,500 psi.) and ductility (reduction in length) 17%.

Comparison of data showed that technical yttrium has higher strength and hardness and somewhat lower ductility than lanthanum, cerium and praseodymium. Yttrium appears to be less pyrophoric than cerium and lanthanum.

Alloys Are Investigated

Since there is no published information on the alloys of yttrium, a preliminary investigation was made of its interaction with the basic components of industrial alloys. For this purpose, alloys were prepared with magnesium, aluminum, cerium, copper, iron, titanium, zirconium, columbium, vanadium, chromium, tantalum and molybdenum. These preliminary investigations indicated the following:

1. Yttrium is completely soluble in cerium.
2. Yttrium forms eutectic combinations in conjunction with aluminum, iron and copper.
3. Its solubility in chromium, titanium and zirconium is low. It has peritectoid reactions in small intervals of composition, and laminates in the solid state at high concentrations of yttrium.
4. Yttrium is practically insoluble in vanadium, columbium, tantalum and molybdenum.
5. In small amounts, yttrium (0.1 to 0.2%) has a grain refining effect on almost all investigated metals. Alloying of aluminum and magnesium by yttrium has a strengthening effect.

Like the other rare earths, it also possesses a de-oxidizing and modifying effect. Thus it is a promising new alloying element.

ARTHUR B. TESMEN

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Model 6836 provides 3 to 15 psi pneumatic output for final control elements, and is available in a complete range of pneumatic control forms, such as on-off, differential gap, narrow proportional band, proportional band with automatic reset, etc.

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Ask your local Weston representative for complete information on these and other Weston instruments for industry, or write for Catalog 08-101-A. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.

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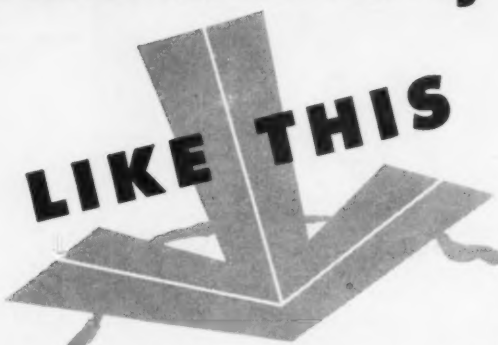
Model 6836 (illustrated) and Model 6833 are supplied in potentiometer or Wheatstone Bridge types. Scale: 320° concentric, 33.86" long. Chart speed: 1, 4, 8, 12, 24, 48 hours or 7 days per revolution.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION

Circle 1211 on Page 48-B

Need Refractory Metals In A Hurry?

FANSTEEL'S NEW WAREHOUSE CAN SHIP Within Hours!



Rocket engine prototype:
an unexpected change with tests due to start in 3 days . . . a call to Fansteel . . . warehouse shipped tungsten sheet within 4 hours, delivery to customer next afternoon.

Chemical pilot plant:
new construction order for 36″ tapered condensers, 1″x18″ single tube bayonet heaters, assorted tantalum screws shipped complete same day received.

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Tantalum Tungsten Molybdenum Columbium Refractory Metal Alloys	wire, rod, foil sheet, plate
Tantalum Chemical Plant Equipment	bayonet heaters, heat exchangers, coils, thermowells, tubing

Also many other products, plus complete processing service, technical assistance.

Write to Metals and Fabrication Division for your copy of the Fansteel Warehouse Price and Stock List . . . or contact your local Fansteel representative.

FANSTEEL
HIGH TEMPERATURE METALS

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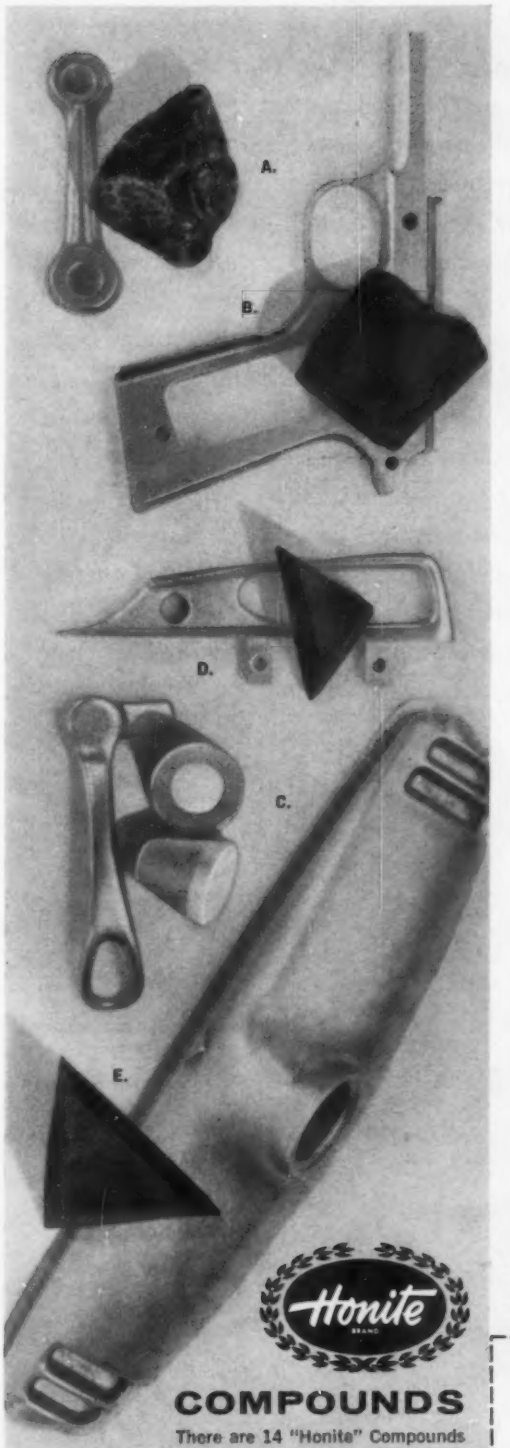
K606

Circle 1212 on Page 48-8



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A. **"HONITE"** – A tough, low cost, long-wearing natural stone containing a micro-crystalline abrasive. Excellent for minor stock removal and burnishing in long run cutting cycles. Available in nine sizes. *The steel alloy outboard motor crankshaft pictured was descaled and smoothed with "Honite" and "Honite" Compound #280 followed by #373.*

B. **"SUPER-HONITE"** – A manufactured chip consisting of a fine-grained, fused aluminum oxide bonded abrasive. Fast cutting and long-wearing – provides a fine, smooth finish on all types of metal. Available in nine sizes. *The hard steel automatic pistol frame was deburred with "Super-Honite" and "Honite" Compound #240; polished with "Super-Honite"and "Honite" Compound #120.*

C. **"HONITE" BRAND CERAMICONES** – A long-wearing porcelain-type, ceramic medium manufactured in precise cone-shaped dimensions. Ideal for deburring, honing, coloring, or burnishing where lodging is a problem. *The yellow brass handle pictured was deflashed and smoothed with "Ceramicones" and "Honite" Compound #300.*

D. **"HONITE" BRAND Z-N TUMBLING SHAPE** – A light-weight medium featuring a new bonding material and extremely fine mesh abrasive. Designed to produce fine surfaces on zinc alloys and other metals prior to plating. Often eliminates the need for costly buffing. *The zinc die-cast locker handle pictured was honed and burnished for plating with "Z-N" 3T Tumbling Shape and a newly developed "Honite": Compound.*

E. **"HONITE" BRAND C-R TUMBLING SHAPE** – A light-weight, fast-cutting medium for use on all metals. Triangular shaped and extremely fracture resistant to prevent lodging. Light weight produces fine, micro-inch finishes without impingement. Available in three sizes. *The aluminum alloy vacuum cleaner head was deburred and prepared for painting with "C-R" 2T Tumbling Shape and "Honite" Compound #240.*

HERE'S HOW you can get the latest information on barrel finishing. VISIT THE "HONITE" BOOTH AT THE NATIONAL METAL EXPOSITION IN PHILADELPHIA OCTOBER 17-21.

COMPOUNDS

There are 14 "Honite" Compounds designed for all types of finishing. Select the compound that fits your needs from these classifications.

1. "HONITE" Abrasive compounds for rapid surface cutting and deburring.
2. "HONITE" Finishing compounds for burnishing, coloring, and light deburring.
3. "HONITE" Cleaning compounds for grease, oil, and scale removal.

Send for FREE booklet

3M COMPANY • 900 Bush Ave., St. Paul 6, Minn.

Gentlemen:
Please send me a copy of your free booklet on "Honite" Barrel Finishing: "There's Gold in Them Thar Barrels."

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

"HONITE" AND "3M" ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.
EXPORT: 99 PARK AVE., NEW YORK 16, CANADA: LONDON, ONTARIO.

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 1213 on Page 48-B

Kanigen®

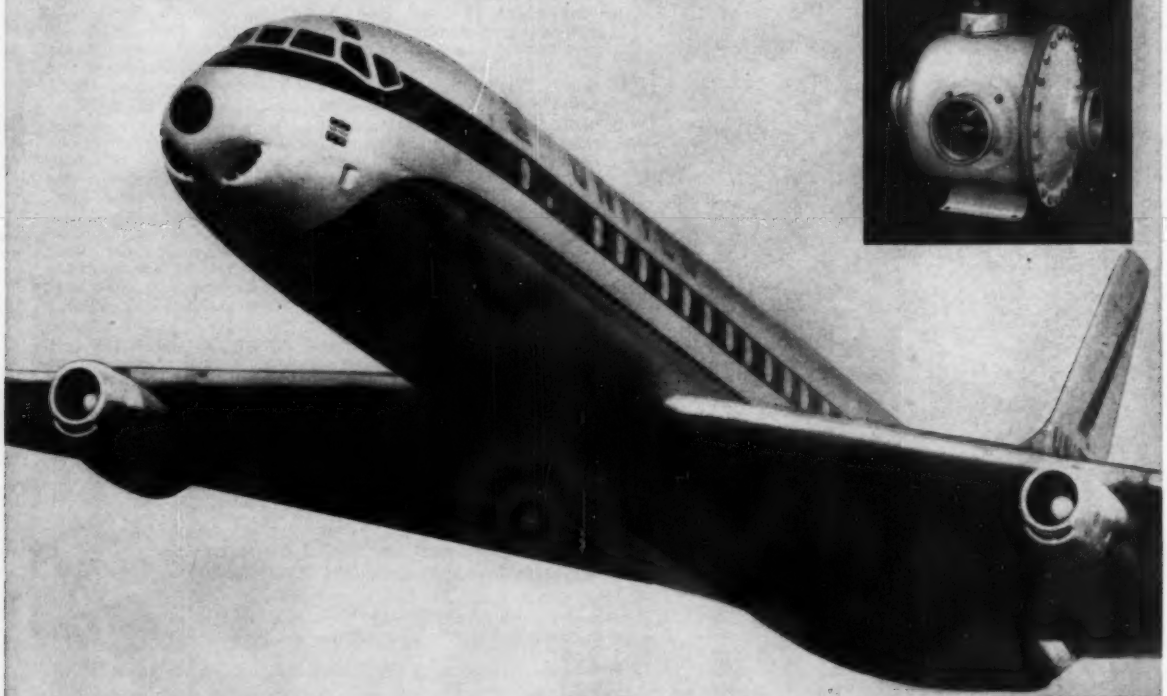
helps keep jet aircraft where the money is ...in the air

Big jet aircraft make money only when they are in the air. Every minute they are earthbound is costly. You just can't take chances on failure of aircraft engines from fuel contamination, or on failure of refueling equipment. That's why those parts of Brodie BiRotor refueling meters and control valves that come in contact with the fuel are chemically plated with KANIGEN nickel alloy.

Brodie BiRotor meters have been used for controlling aircraft refueling for many years, and their internal parts have been KANIGEN-coated ever since this highly accurate method of plating difficult or complicated surfaces was perfected.

Do you have a corrosion or contamination problem? Is it a small part like the Brodie meter housing? Or is it a surface as large as the inside of a 20,000 gallon tank car? Whatever it is, there's a way to solve your problems with KANIGEN chemical nickel plating. Write or phone the nearest General American office.

It pays to plan with General American.



GENERAL AMERICAN TRANSPORTATION

KANIGEN DIVISION
CORPORATION
135 South LaSalle Street
Chicago 3, Illinois
Offices in principal cities

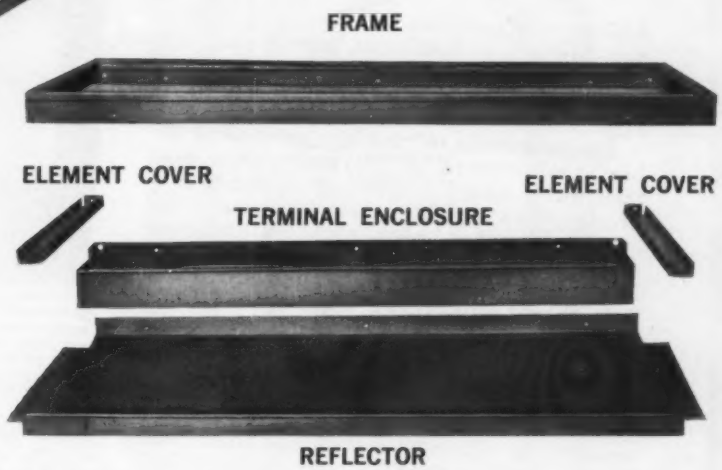
KANIGEN GENERAL AMERICAN

Circle 1214 on Page 48-B

Economical, reflective Armco ALUMINIZED STEEL gives multiple benefits in new infrared heater

COMPLETE UNIT

This new self-contained infrared heating unit is used for drying, baking, curing, and preheating. The heating element is tempered glass coated with an electrically-conductive film. The long-wave-length heat given off is readily absorbed by materials of all colors. All major metal parts—reflector, frame, terminal enclosure and element covers—are made from Armco ALUMINIZED STEEL Type 1.



This new self-contained infrared heating unit heats quickly and uniformly, requires minimum maintenance, remains permanently strong—yet is built at reasonable cost. The reason: nearly everything except the glass is fabricated from Armco ALUMINIZED STEEL Type 1.

Add these features to your products

1. **Heat reflectivity**—ALUMINIZED STEEL bounces back about 80 per cent of radiant heat that meets it.
2. **Strength**—Because they are steel-strong, units remain rigid at operating temperatures even when they are made from lighter gages than are required with softer heat-reflective metals.
3. **Rust-resistance**—A special aluminum coating that guards against corrosion.
4. **Reasonable cost**—Light-gage strength means material savings; elimination of painting speeds production and lowers costs.

Investigate the unique advantages of this material for your products today. Just call the nearest Armco Sales Office or fill in and mail the coupon.

New steels are born at Armco

ARMCO STEEL CORPORATION
2620 Curtis Street
Middletown, Ohio

Send me the catalog, **Armco ALUMINIZED STEEL Type 1.**

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

Circle 1215 on Page 48-B

CARBORUNDUM'S TECHNICAL INFORMATION ON UNUSUAL REFRACTORIES *Data sheet*

How to make use of

THERMAL CONDUCTIVITY

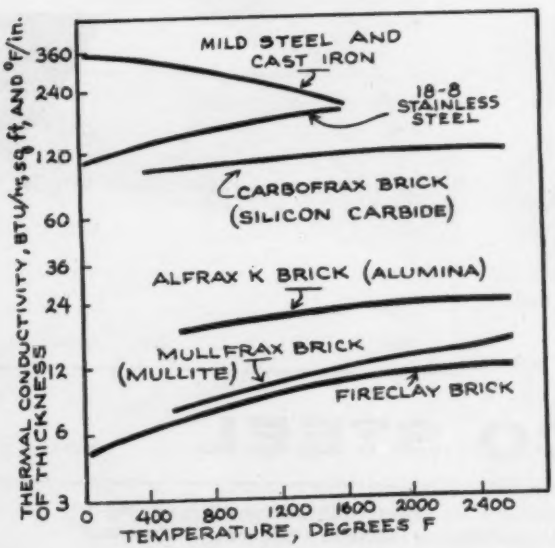
Although refractories are usually considered heat barriers, or insulators, some are actually excellent heat conductors. This conductivity factor can be used with advantage in many applications.

Silicon carbide refractories are among the best heat conductors known—with a heat transfer at 2200 F. roughly 11 times that of fireclay brick and 70% that of chrome-nickel steels. However, high nickel alloys lose strength rapidly above 1500 F. Silicon carbide refractories can be safely used above 2800 F. and still provide a fast rate of heat transfer.

Employed in an indirectly-heated application like a muffle, the much better heat conductivity of silicon carbide refractories can result in substantial fuel savings. For example, a silicon carbide 1½" thick wall needs a hot-face temperature of only 1571 F. to maintain a 1500 F. temperature in the work chamber. A fireclay wall of equal thickness would require a hot face temperature of 2337 F. Superior conductivity makes possible closer temperature control, particularly where conditions tend to produce wide temperature swings.

Comparison of heat conductivity shows that water boils turbulently on CARBOFRAX® silicon carbide brick; barely gets tepid on fireclay. Heat conductivity of CARBOFRAX brick is roughly 11 times that of fireclay and about 70% that of chrome-nickel steel. Thermal conductivity of CARBOFRAX brick is 109/Btu hr., sq. ft. and °F/in. of thickness.

The chart at left shows thermal conductivity of various Carborundum refractories—including silicon carbide, alumina, and mullite—as opposed to metals and fireclay brick. For the refractory best suited to your particular application, feel free to call on Carborundum's accumulated experience.

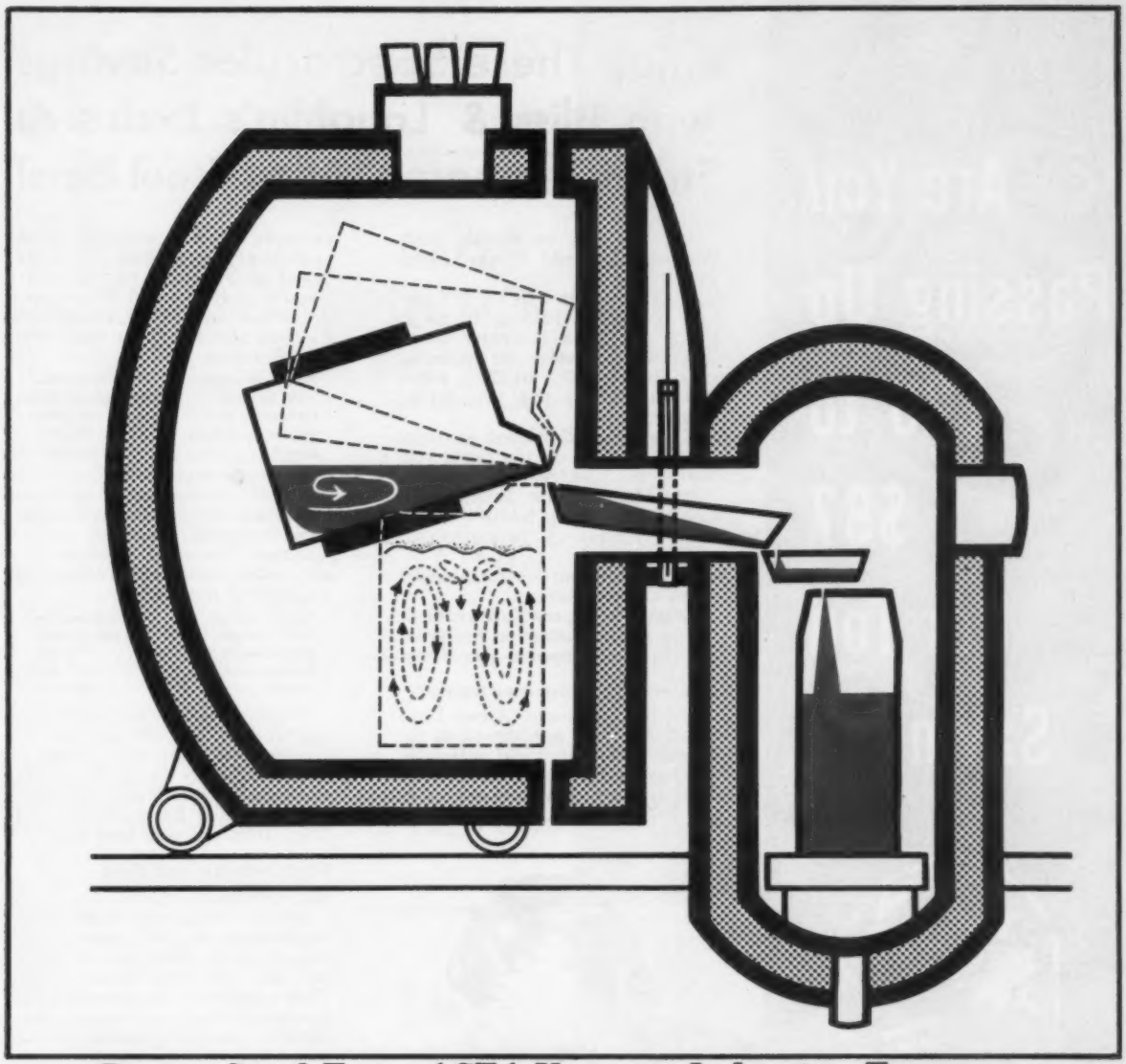


Coefficients of thermal conductivity for some of Carborundum's refractories and other materials at different mean temperatures. Information adapted from Figure 4, Carborundum "Refractories" Vol. 3, No. 5, December 1958. This bulletin, containing extensive technical information on the properties and applications of refractory-type products, is published bi-monthly. A request will put you on the mailing list.

Write today for your free copy of "Super Refractories by Carborundum." The address: Dept. M-90, Refractories Division, Perth Amboy, N. J.

For engineered refractories, count on **CARBORUNDUM®**

Circle 1216 on Page 48-B



Better Steel From ASEA Vacuum Induction Furnaces

U.S. installation of 1100 kW, 5000 lbs. ASEA High Vacuum Furnace. Front View

Induction melting in vacuum makes steel of high heat resistance, increased fatigue strength and higher yield points. In High Vacuum melting, only ASEA offers all the following advantages: ■ Accurate composition control of melt. ■ Poly-phase, low-frequency Induction Stirring increases homogeneity and purity of melt without temperature increase. ■ Accurate Temperature Control throughout process. ■ Reduced Degassing Time increases steel production. ASEA builds induction furnaces for vacuum melting up to 5,000 lbs. for air melting to 55,000 lbs. ASEA—one organization manufacturing and marketing all electrical and mechanical furnace equipment. Write for folder:

ASEA
ELECTRIC INC.
500 Fifth Ave., New York 36, N. Y.

Circle 1217 on Page 48-B

Are You Passing Up $29 to $87 Per Ton Savings?

Enjoy These Spectacular Savings with Bliss & Laughlin's Exclusive Strain-Tempered® Alloy Steel Bars!

Do you buy or specify heat treated alloy cold finished steel bars?

You can save $29 to $87 per ton by substituting Bliss & Laughlin's Strain-Tempered Alloy.

That's a savings on material cost alone of 10% to 25%, without sacrificing the properties wanted most.

There are additional savings, too, depending on the parts you make from heat treated alloy bars.

Machining goes faster with less tool wear. Up to 30% better machinability is common experience.

Heat treatment costs on finished parts are eliminated.

Straightening costs are avoided. There are no distortion problems with Strain-Tempered Alloy Bars.

Pay only for properties needed

Strain-Tempered Alloy Bars meet the same specifications for tensile strength, yield strength, fatigue strength and hardness as heat treated alloy bars with $29 to $87 less cost per ton. For example, in the strength most commonly specified for heat treated alloy bars, Strain-Tempered 4140 and 5150 are produced in all sizes of rounds through 3½" to the following *minimum* specifications:

Tensile Strength	125,000 psi Min.
Yield Strength	105,000 psi Min.
Elongation in 2"	14% Min.
Reduction of Area	45% Min.
Brinell	269/321

As can be seen, for 10% to 25% less cost, Strain-Tempered Alloy Bars meet all physical properties most frequently specified.

Strain-Tempered 4140 is also available with the following mechanical properties:

Tensile Strength	145,000 psi Min.
Yield Strength	125,000 psi Min.
Elongation in 2"	12% Min.
Reduction of Area	40% Min.
Brinell	286/321

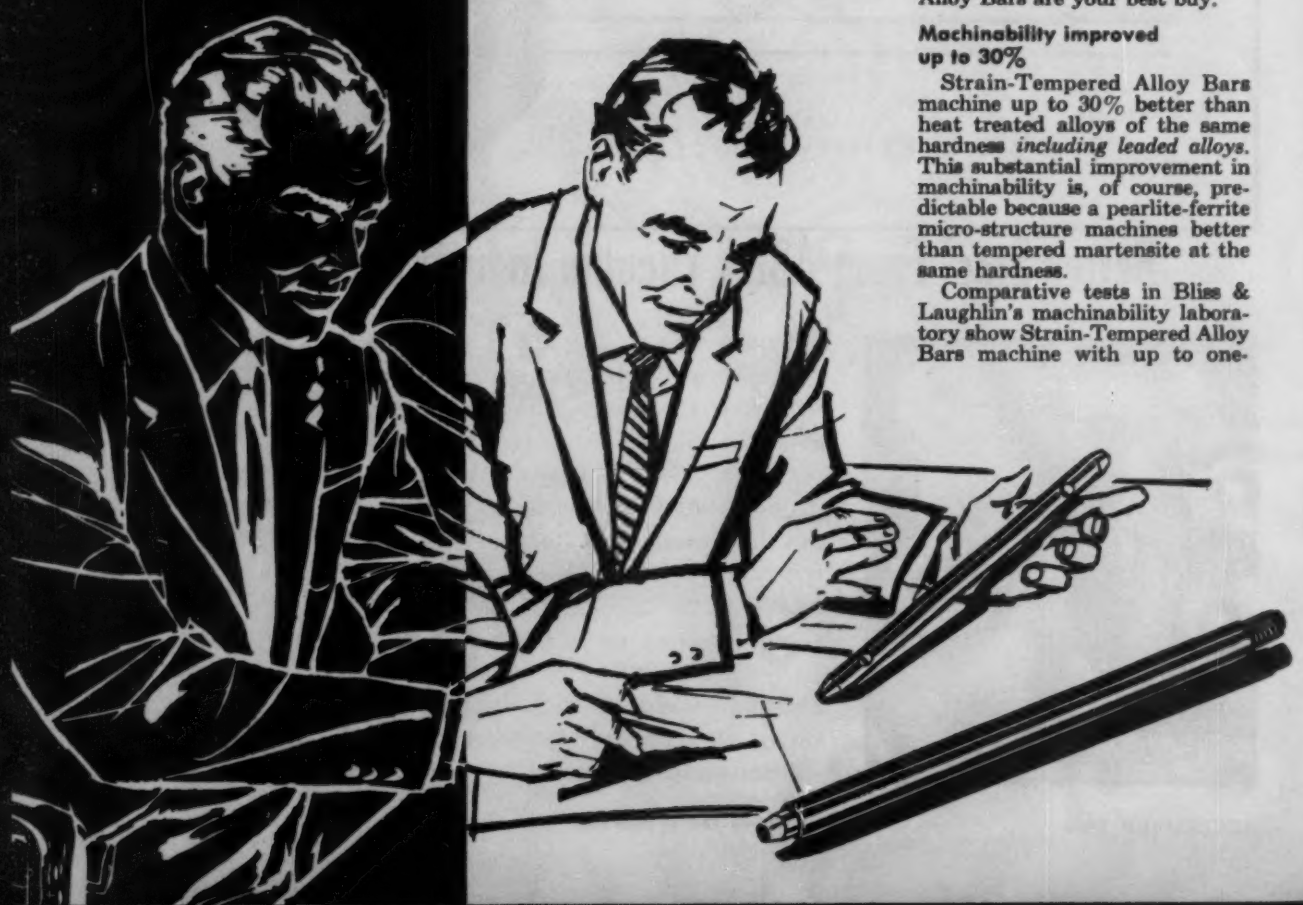
Higher tensile strength levels, approaching 200,000 psi, can be furnished at attractive prices.

You pay only for the properties you actually need. That's why Bliss & Laughlin's Strain-Tempered Alloy Bars are your best buy.

Machinability improved up to 30%

Strain-Tempered Alloy Bars machine up to 30% better than heat treated alloys of the same hardness *including leaded alloys.* This substantial improvement in machinability is, of course, predictable because a pearlite-ferrite micro-structure machines better than tempered martensite at the same hardness.

Comparative tests in Bliss & Laughlin's machinability laboratory show Strain-Tempered Alloy Bars machine with up to one-



third less power consumption, show better chip characteristics, produce cooler parts and assure longer tool life than heat treated alloys at equal hardnesses.

Available in all finishes

Strain-Tempered Alloy Bars are available with these finishes:
Cold Drawn
Ground and Polished
Turned and Polished
Turned, Ground and Polished

Less lead time required

Lead time is substantially less than required for regular heat treated alloy bars. This is another big advantage of specifying Strain-Tempered Alloy Bars. Strain-Tempered Alloy Bars are usually manufactured to customers' specifications. However, some of the most commonly used grades in popular sizes will soon be available at Steel Service Centers, which have stocked Strain-Tempered Carbon Bars for years.

What are Strain-Tempered Bars?

Strain-Tempered Alloy Bars are manufactured by a special process of drawing and furnace treatment. This produces strength and hardness levels usually obtained only by quench-and-temper heat treatment. Furnace aging at the ideal temperature for at least four hours in large, modern annealing furnaces assures maximum uniformity and minimum distortion.

Pioneered by Bliss & Laughlin

High-strength, furnace-treated steel bars were pioneered by Bliss & Laughlin over 30 years ago. Today, Strain-Tempered bars are produced in both alloy and carbon grades.

The first Strain-Tempered bar was delivered in 1929 for automobile drive shafts. Large quantities of Strain-Tempered Alloy Bars are now being furnished for drive shafts, as well as for many other products.

Nearly 70 years of research and development leadership back Bliss & Laughlin's Strain-Tempered production.

Investigate your savings now

A Bliss & Laughlin representative will recommend the most suitable, least costly grade. He will present tangible evidence, without obligation, of how Strain-Tempered Alloy Bars can cut your material and production costs. Contact your nearest Bliss & Laughlin sales office or mill today.

SAVES $64/TON

TRUCK BODY PIN

2¼" round 4140 heat treated, stress relieved, 269/321 Brinell. Strain-Tempered 5150 saves $64.00 per ton.

SAVES $49/TON

WINCH SHAFT

1¾" round 5150 heat treated, stress relieved, Drawn, Ground and Polished, 262/311 Brinell. Strain-Tempered 5150 reduces material costs $49.00 per ton.

SAVES $87/TON

MACHINERY SHAFT

2¾" round 4140 leaded, heat treated, stress relieved, 269/321 Brinell. Strain-Tempered 5150 saves $87.00 per ton.

SAVES $49/TON

STUD

1½" round 4140 heat treated, stress relieved, 240/283 Brinell. Strain-Tempered 4140 cuts $49.00 per ton from material costs.

SAVES $29/TON

CHROME PLATED HYDRAULIC PISTON ROD

2.252/2.258" round 4140 heat treated, 269/321 Brinell. Strain-Tempered 4140 lowers costs $29.00 per ton.

SAVES Added Costs

MACHINE TOOL SHAFT

1½" round 4140 annealed and cold drawn, then heat treated and straightened after fabrication. Strain-Tempered 4140 saves the cost of heat treatment and straightening.

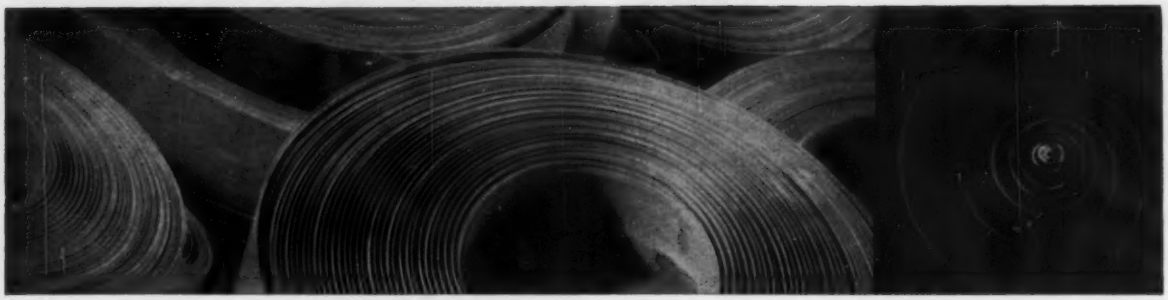
Specialists in Finish, Accuracy, Straightness, Strength and Machinability

BLISS & LAUGHLIN

Leading Independent Producer of Cold Finished Steel Bars

GENERAL OFFICES: Harvey, Ill. • MILLS: Harvey, Detroit, Buffalo, Los Angeles, Seattle, Mansfield, Mass.

Circle 1218 on Page 48-B



Check your requirements against these

Wallace Barnes Cold-rolled Specialty Steels

Furnished in these carbon grades:

1.25 – 1.32% .90 – 1.05% .70 – .80% .59 – .74% .48 – .55%

ANNEALED AND HARD-ROLLED

Thickness

.003 – .010″	in widths	1/8 to 6 1/4″	
.011 – .014″	“ “	3/16 to 11″	
.015 – .019″	“ “	3/16 to 13″	
.020 – .035″	“ “	1/4 to 13″	
.036 – .049″	in widths	3/8 to 13″	
.050 – .064″	“ “	1/2 to 13″	
.065 – .093″	“ “	3/4 to 6 1/4″	
.093 – .125″	“ “	3/4 to 6 1/4″	

HARDENED AND TEMPERED

Scale-free or scaleless; polished*; polished and blued*; polished and strawed*

Thickness

.003 – .004″	in widths	1/8 to 2″	
.005 – .007″	“ “	1/8 to 3″	
.008 – .009″	“ “	1/8 to 4″	
.010 – .014″	“ “	3/16 to 5″	
.015 – .019″	“ “	3/16 to 7″	
.020 – .025″	“ “	1/4 to 8 1/2″	
.026 – .030″	“ “	1/4 to 8″	
.031 – .035″	in widths	1/4 to 7″	
.036 – .040″	“ “	3/8 to 7″	
.041 – .049″	“ “	3/8 to 6″	
.050 – .060″	“ “	1/2 to 4″	
.061 – .064″	“ “	1/2 to 3″	
.065 – .093″	“ “	3/4 to 3″	

*Maximum width for polishing in .010 – .030 thickness ranges is 5 in.

Facilities for processing alloy steels also are available.

Standard sizes normally available for prompt shipments.

Write for a copy of “Physical Property Charts” that give performance characteristics of .90 – 1.05% and .70 – .80% carbon grades.

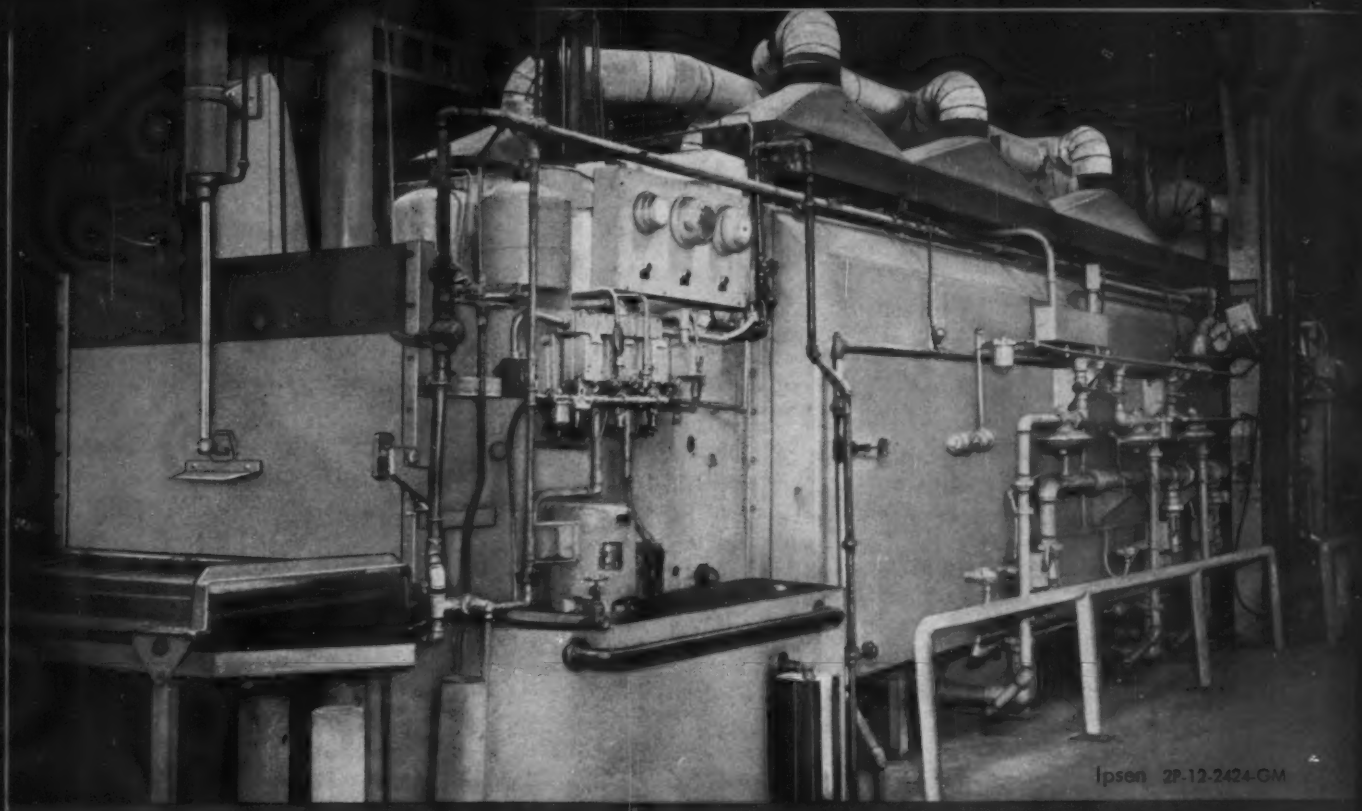
Wallace Barnes Steel Division

Bristol, Connecticut

Associated Spring Corporation

8818

Circle 1219 on Page 48-8



PRODUCTION carburizing

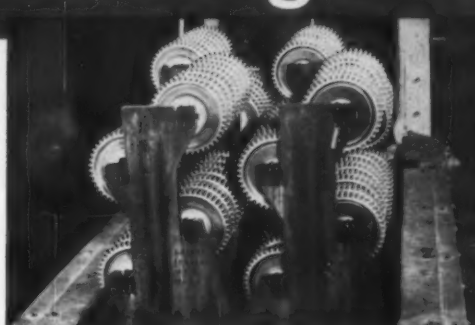
Five years ago the first Ipsen Double Row 4-Zone Pusher was built. It is now six years since the first Deep Case Carburizing Unit was built. BIG Ipsen controlled atmosphere pushers have given unexcelled metallurgical results!

Check these features when you consider a carburizing furnace. They are exclusive with Ipsen.

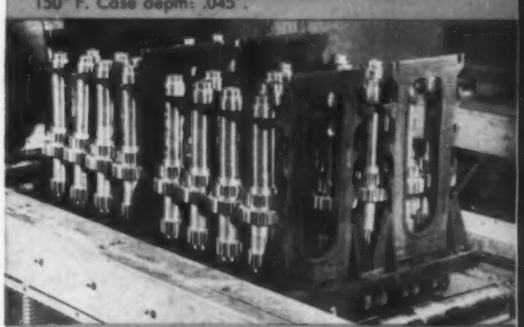
- Enclosed Charging Mechanism (Pat. No. 2,896,775)
- Chain Discharging Mechanism (Pat. No. 2,842,349)
- Baffles for 100% Forced Convection Heating (Pat. No. 2,788,205)
- Ceramic Heating Tube Mounting (Pat. No. 2,822,798)
- Ceramic "Flame-Busters" (Pat. No. 2,861,596)
- Ceramic Fan (Pat. No. 2,730,352)
- Water-Cooled Fan Motor (Pat. No. 2,800,317)
- Quench Oil Flow System (Pat. No. 2,854,013)

Other Patents Pending

Ipsen Pusher furnaces are described in Bulletin P-59. Send for your copy today.



This charge of steel gears is typical of work handled in Ipsen Production Carburizing Furnaces. Heating was 1700° F for 10 hours. Quenching was in oil at 150° F. Case depth: .045".



Countershafts ready for charging into Ipsen Production Carburizing Furnace. Heating time was 10 hours at 1700° F; quenching was in oil at 150° F. Case depth: .045".

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • DEPT. 23 • P.O. BOX 500 • ROCKFORD, ILLINOIS

Circle 1220 on Page 48-B

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Thermal Stress-Relieving of Alloy Steels

In the production of alloy steel bars and parts made of alloy steel, stresses are sometimes set up, and these stresses must be relieved before optimum results can be expected. Two general types of stress-relieving are practiced—thermal and mechanical. In this discussion we shall consider only the former.

There are several important reasons for thermal stress-relieving. Among these are the following:

(1) The first and most fundamental purpose is to reduce residual stresses that might prove harmful in actual service. In the production of quenched and tempered alloy steel bars, machine-straightening is necessary. This induces residual stresses in varying degrees. Bars are usually stress-relieved after the straightening operation. When the bars are subjected to later processing that sets up additional stresses, subsequent stress-relieving may be necessary.

(2) A second major purpose of thermal stress-relieving is to improve the dimensional stability of parts requiring close tolerances. For example, in rough-machining, residual stresses are sometimes introduced, and these should be relieved if dimensional stability is to be assured during the finish-machining.

(3) Thermal stress-relieving is also recommended as a means of restoring mechanical properties (especially ductility) after certain types of cold-working. Moreover, it is required by the "safe-welding" grades of alloy steels after a welding operation has been completed.

Alloy bars are commonly stress-relieved in furnaces. Temperatures under the transformation range are employed, and they are usually in the area from 850 deg to 1200 deg F. The amount of time required in the furnace will vary, being influenced by grade of steel, magnitude of residual stresses caused by prior processing, and mass effect of steel being heated. After the bars have been removed from the furnace, they are allowed to cool in still air to room temperature.

In the case of quenched and tempered alloy bars, the stress-relieving temperature should be about 100 deg F less than the tempering temperature. Should the stress-relieving temperature exceed the tempering temperature, the mechanical properties will be altered.

Items other than bars (parts, for example) can be wholly or selectively stress-relieved. If the furnace method is used, the entire piece is of course subjected to the heat; selective relieving is impossible. However, if a liquid salt bath or induction heating is used, the piece can be given overall relief or selective relief, whichever is desired.

Detailed information about stress-relieving is available through Bethlehem's technical staff. And remember that we can furnish the entire range of AISI standard alloy steels, as well as all carbon grades.

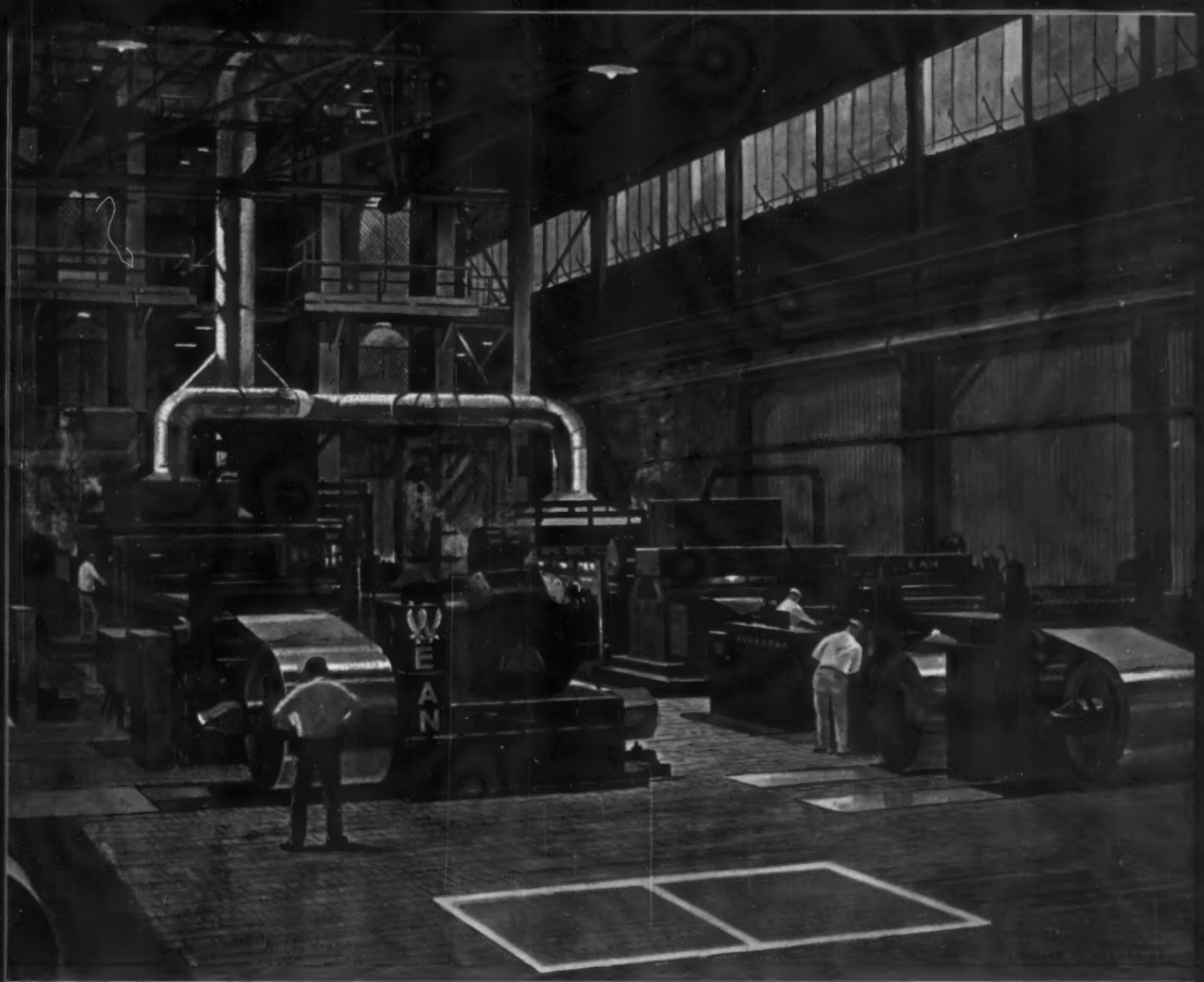
This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Circle 1221 on Page 48-B



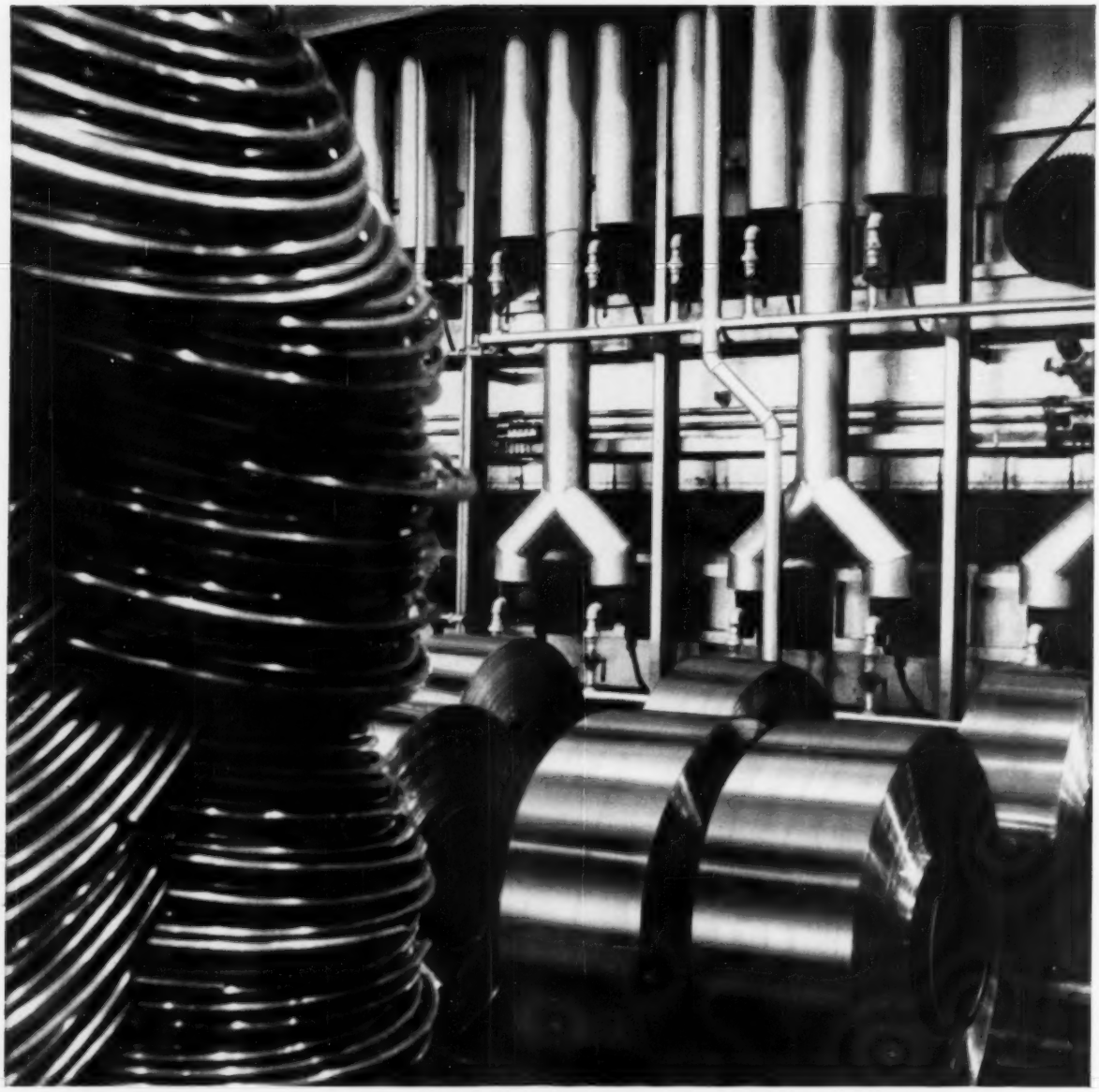
No. 5 and 6 continuous silicon annealing lines, Vandergrift plant, U. S. Steel Corporation

Wean, U.S. Steel and Silicon Annealing . . .

The two silicon annealing lines featured above—and a third line in an adjacent building—were recently installed at the Vandergrift plant of United States Steel. Precision-engineered by Wean Engineering Company, these new lines are designed to assure exact molecular consistency of the strip for the required electrical properties of grain-oriented silicon material.

U. S. Steel's silicon annealing lines are among the many continuous annealing lines designed by Wean for the American steel industry. Every major steel company in this country has used Wean continuous process equipment in supplying its customers' needs; many of these installations being specifically designed to satisfy unique requirements. Whether your production planning involves silicon annealing or some other type of continuous strip processing, Wean's experience and *creative engineering* can work for you.

THE WEAN ENGINEERING COMPANY, INC. • WARREN • OHIO

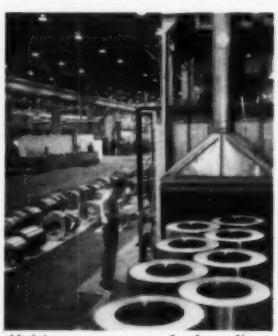


American Brass relies on GAS for precise control in heat processing

Five huge gas-fired furnaces handle heat processing at the new American Brass Company plant near Los Angeles—largest copper and brass mill in the West.

Gas heat anneals their copper and brass coils, tubing and strip . . . processes copper billets for extrusion and for piercing . . . and bright-finish anneals copper coils and tubing.

Why the choice of gas heat? Precise temperature control! Gas heat develops the required temperatures rapidly. Maintains them precisely. Adapts most easily to automatic temperature control. Offers unbeatable fuel economy.



Multi-purpose, gas-fired, radiant tube, forced circulation roller hearth furnace at American Brass Company's new Los Angeles mill. Used in the bright finish annealing of copper coils, tubing and strip.

American Brass, and thousands of other companies, can tell you *gas* is technically right and economically sound for all types of heat processing. Call the Industrial Sales Engineer at your local gas company. *American Gas Association.*

FOR HEAT PROCESSING GAS IS GOOD BUSINESS!

Circle 1222 on Page 48-B

What HORACE DREVER has to say about Lindberg heat treating equipment

Mr. Horace Drever, internationally prominent in the industrial heating field, is a Past-President of the Furnace Manufacturers Association and President of Drever Company, furnace manufacturers and commercial heat treaters.

QUOTE from Mr. Drever's unsolicited letter to Lindberg Engineering Company

"For the past three and one-half years, we have been operating one of your Type 243618 GVRT Furnaces along with a 500 CFH Lindberg Hyen generator in our commercial heat treating division. We are extremely pleased, not only with the fine quality of work turned out by this equipment but also its relatively trouble-free operation. As evidence of our complete satisfaction we have ordered another Lindberg Furnace of this type."

Lindberg Furnaces in operation at the Drever Company, Bethayres, Pennsylvania.

We are happy that Mr. Drever, a furnace manufacturer in his own right, originally chose Lindberg equipment for his heat treating plant and that its satisfactory service prompted an additional order. The second Lindberg Furnace is now in production at Drever Company, as the adjacent photo shows. Bless those satisfied customers! If you have a product or process in the metal or ceramic field requiring the application of heat you can depend on Lindberg's engineering and design know-how to provide exactly the right equipment to answer your need. Get in touch with your nearest Lindberg Field Representative (see classified phone book) or write direct to Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant 11937 South Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg, Ltd., Toronto.

LINDBERG
heat for industry

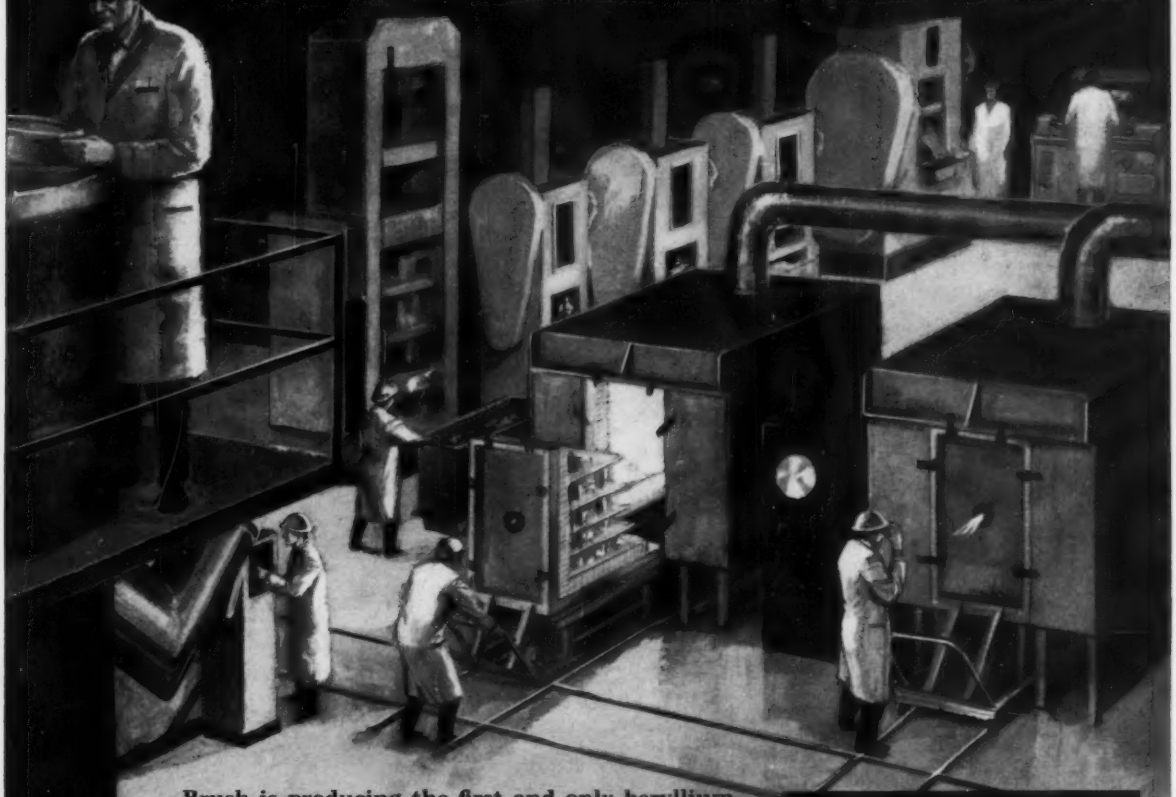
Circle 1223 on Page 48-S

SIGNIFICANT ADVANCES IN BERYLLIUM TECHNOLOGY COME FIRST FROM BRUSH

A MATERIAL FIRST

BRUSH UOX®

THE ONLY SINTERABLE HIGH-STRENGTH BERYLLIUM OXIDE



Brush is producing the first and only beryllium oxide that is both sinterable and 99.95+% pure. This combination means that manufacturers of nuclear, electronic, and aero/space components can now mass produce ceramics taking full advantage of beryllium oxide's remarkable properties.

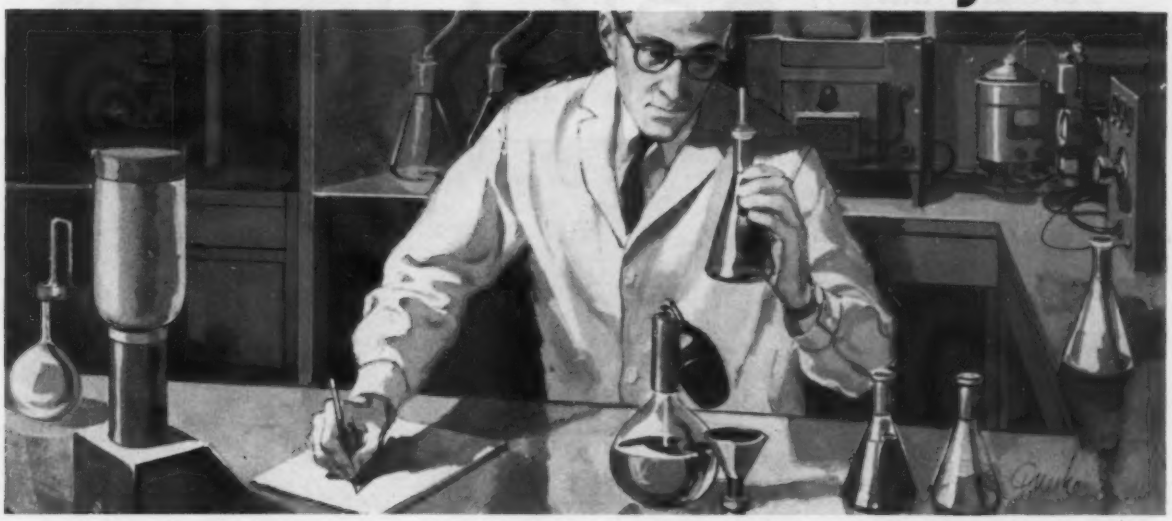
BeO is an excellent reflector and moderator of neutrons. Its unique thermal properties include room temperature conductivity superior to most metals. It has good strength, a melting point of 4658° F., and is inert to chemical attack.

More detailed information on versatile UOX® is yours for the asking. Contact us at ENdicott 1-5400 or 5209 Euclid Avenue in Cleveland, Ohio, and we will show you how beryllium oxide can fit into your requirements for high-performance ceramic components.

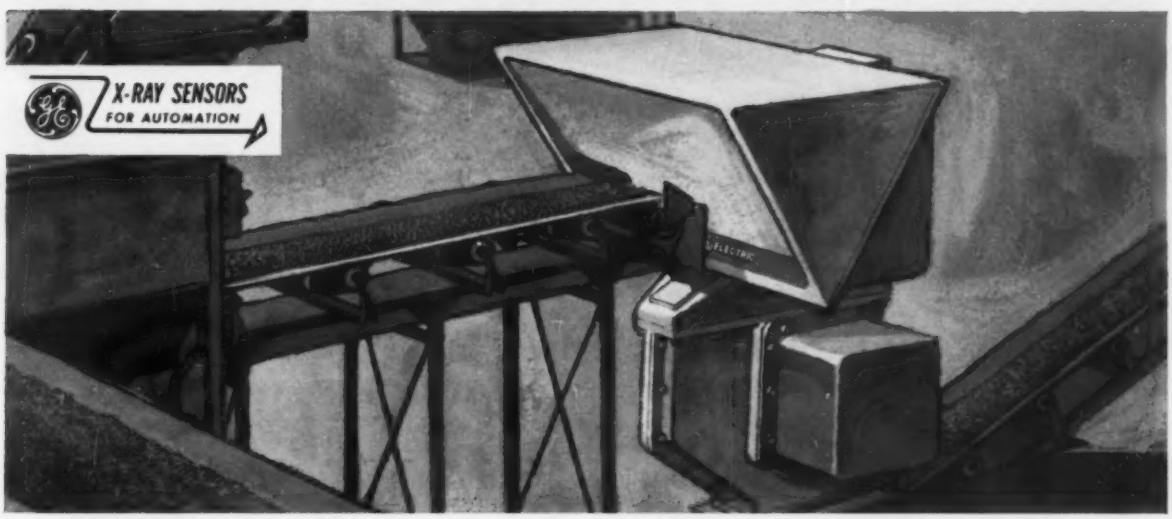
Any shape that can be fabricated by standard ceramic production methods can be produced in UOX® beryllium oxide.

THE BRUSH BERYLLIUM COMPANY

"XEG" moves materials analysis



out of the lab...



onto the line!

General Electric's revolutionary X-Ray Emission Gage offers what amounts to an "on-line" *laboratory* for quality control. XEG performs continuous analysis of solids, liquids, liquid mixtures, slurries, powders, sheets, rods, wire or similar materials *during actual production.* It monitors up to 5 selected elements . . . maintains *moment-by-moment* surveillance, sensing both presence and quantity.

Expressly intended for the production line, XEG also is suited to individual sample analysis. Operation requires no scientifically trained personnel . . . facts on composition are delivered automatically, instantly, for rapid-fire feedback to process control.

You'll find uses of XEG as unlimited as the imagination! Discover how you can take full advantage of this remarkable innovation — get complete information now from your local G-E representative. Or write to X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, Room AS-94.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 1225 on Page 48-8

For heavy-duty protection under paint

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS

Oakite CrysCoat® zinc phosphate coatings keep rain and rust from ruining steel

Oakite CrysCoat *zinc* phosphate pre-paint treatment provides lasting corrosion resistance beneath paint under all kinds of heavy punishment.

First, it locks paint and steel together. Then, it beats back corrosion at any point of future paint damage. Test panels usually last well over 1,000 hours in salt spray tests—*four times* the 250 hours required by government specifications.

CrysCoat zinc phosphate coatings are easy to control, too. You use only *one* material for make-up . . . the *same* material for up-keep . . . only *one* simple titration test for analysis—no chance to go wrong on material, or with the wrong concentration.

In the family of Oakite CrysCoat processes there are zinc phosphate as well as iron phosphate materials . . . for spray application and for tank dip . . . for room temperature or heated operation.

You can count on *all* to give products lasting protection, lasting appeal. But there's a *right* one to match your protection and/or economic requirements. Ask the Oakite man to help you select it. Meanwhile, write for Bulletin F-8979. Oakite Products, Inc., 38H Rector Street, New York 6, N. Y.

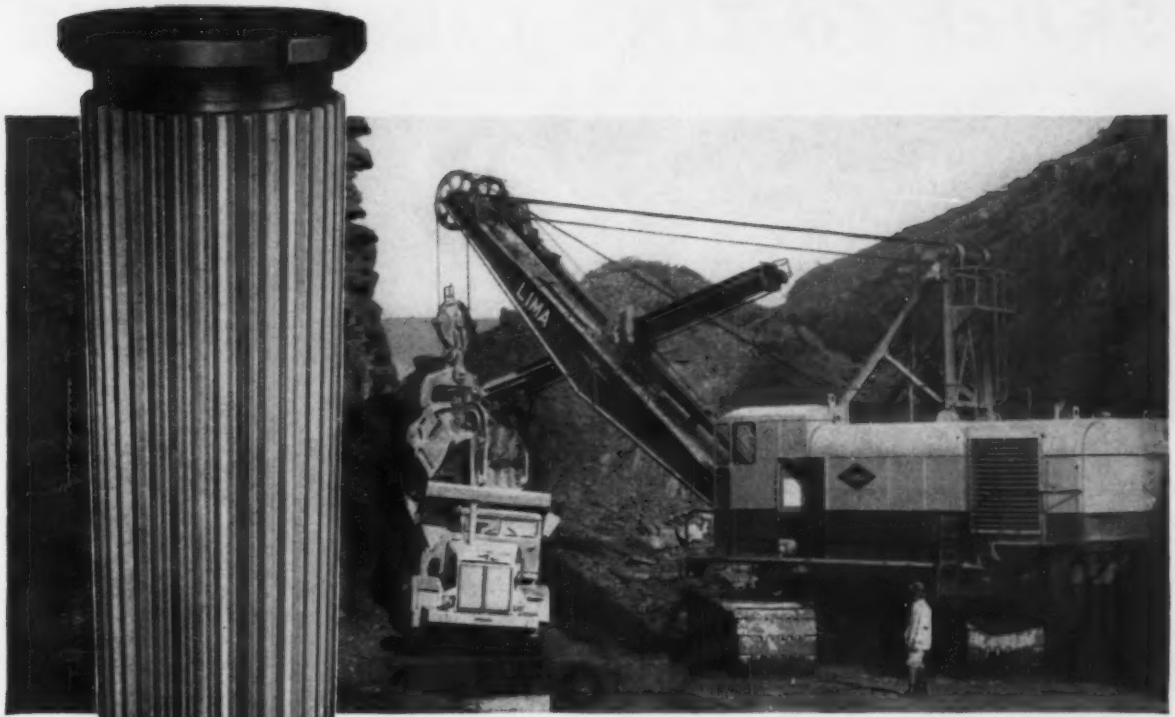
it PAYS to ask Oakite

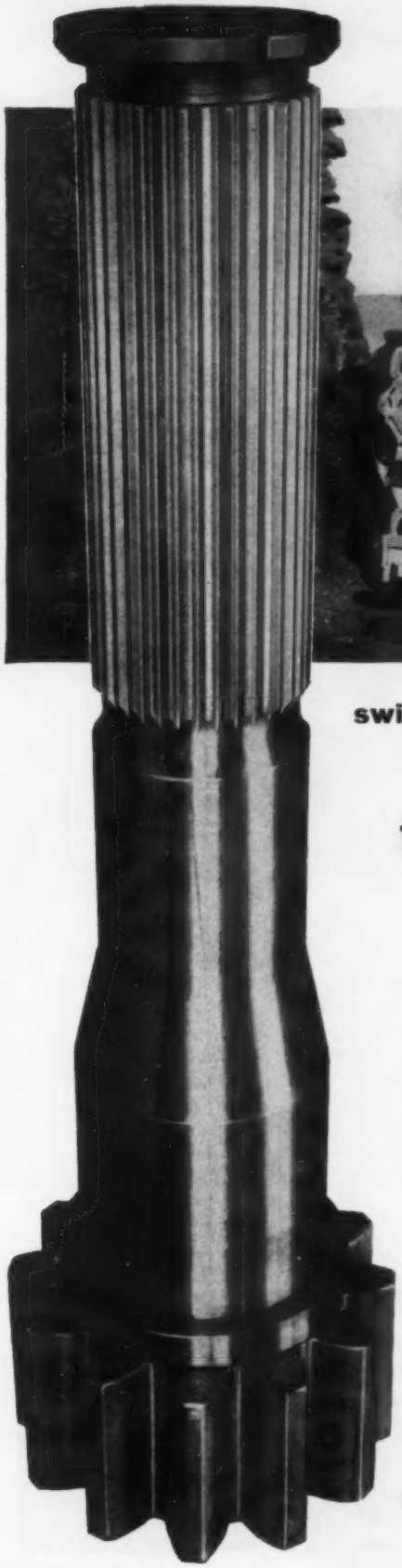
OAKITE

over 50 Est. 1909 SCIENCE

years' leadership in industrial cleaning

Circle 1226 on Page 48-8





swing! stop! swing!

4340 nickel alloy steel takes shock-loading in stride

Every time the big Lima Type 2400 turns to dig or dump, this 9"-diameter, 36"-long swing shaft of 4340 nickel alloy steel transmits tremendous torque to a giant ring gear, to swing the rotating assembly smoothly and speedily.

Through-hardening 4340 nickel alloy steel gives this swing shaft the strength, the toughness, the uniform hardness, to stand up to hundreds of swing-stop-swing cycles every working day.

And because 4340 is readily machined at high hardness, both spur pinion and spline are machined on the shaft *after* heat treatment. The resulting one-piece component provides an extra measure of dependability; it permits splined mounting of gears on shafts with close, accurate fit, plus even distribution of shaft stresses.

For your medium-to-heavy section parts, you'll find 4340 nickel alloy steel delivers the high mechanical properties that make for trouble-free performance in the toughest service. Available right off the shelf at Steel Service Centers, this versatile through-hardening steel is ready for immediate delivery in a wide selection of sizes. Other nickel alloy steels, possessing special properties for specialized applications, are also widely available.

Next time you're faced with heavy wear and loading problems—such as in earth-moving equipment or motor-vehicle applications—remember Nickel alloy steels. *They can take it.*

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street New York 5, N. Y.

INCO NICKEL

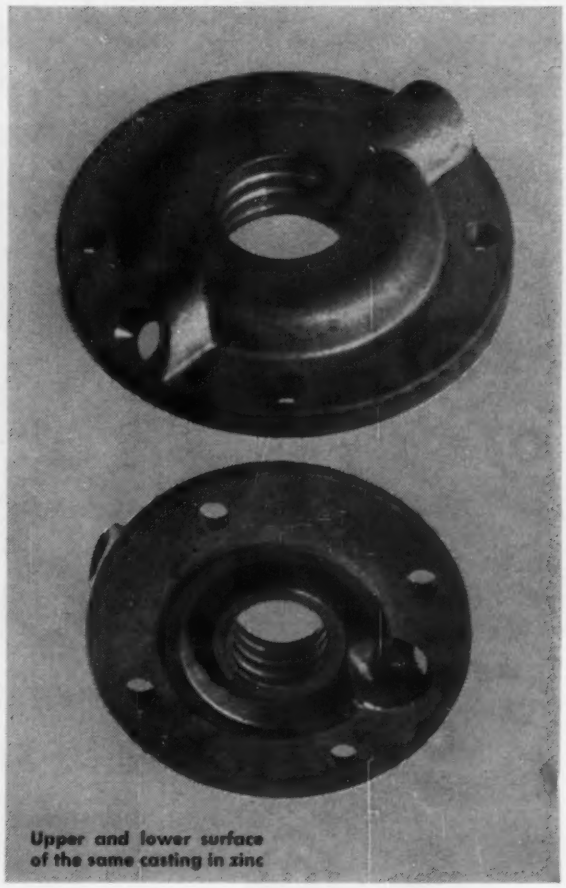
NICKEL MAKES STEEL PERFORM BETTER LONGER

Circle 1227 on Page 48-8

Switch To ZINC DIE CASTING

From Cast Iron CUTS PRODUCTION COSTS *Substantially*

Cast iron retainer ring



Upper and lower surface of the same casting in zinc

Eliminate costly machining operations. Improve your product. That's precisely what St. Louis' Baldor Electric Co. did when they switched to zinc alloy die castings for their electric motor bearing lock rings.

Formerly the rings were sand cast in iron. To complete each ring required four machining operations: 1. Face milling; 2. Machining of a locating ring groove; 3. Boring a shaft hole; 4. Drilling screw holes. Other disadvantages of the sand castings included dimensional inaccuracy, rough appearance and a high reject rate due to porosity.

The switch to zinc die castings brought advantages which more than offset the difference in cost of basic material:

1. Elimination of machining. 2. Higher speed of production. 3. Close "as cast" dimensional tolerances. 4. High corrosion resistance. 5. Superior appearance.

The rings are die cast to exact size, with the bore holes and locating rings held to .002". The cored screw holes are cast to size in the same operation. They are cast in three sizes by the A. B. Mueller Co. of St. Louis, Mo. Each size is cast in a two-cavity die as annual production requirements are 36,000 of each size at the rate of 160-180 shots per hour.

DIE CASTING is the Process . . . ZINC, the metal . . .

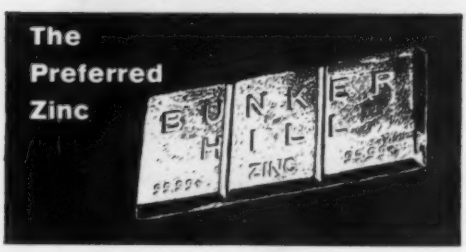
BUNKER HILL

Eastern Sales Agents:
ST. JOSEPH LEAD CO. • 250 Park Avenue • New York 17, N. Y.

BUNKER HILL 99.99+% ZINC

Sales Office For The Pacific Coast
THE BUNKER HILL CO. • 660 Market St. • San Francisco, Calif.

ZN-150



Circle 1228 on Page 48-B

It takes the right atmosphere to develop brightness in stainless steels during annealing. Dry hydrogen will do it, but a dry N_2-H_2 atmosphere from anhydrous ammonia will do it at less cost. It is the *least* expensive way to supply large volumes of gaseous nitrogen and hydrogen for atmospheres that prevent formation of scale and assure a bright, clean finish.

Allied Chemical Anhydrous Ammonia, dissociated to form a *protective* atmosphere, prevents carburization of metal . . . as a *finish* atmosphere, it prevents discoloration.

It is ideal for: annealing nickel and nickel alloys; electrical steels; beryllium copper; silicon copper; and other copper alloys. Dissociated ammonia is excellent for clean hardening of high carbon and high chrome tool steels . . . for copper brazing of all types of ferrous metals . . . for sintering metal powders.

Our experience with ammonia is unsurpassed by any other producer in this field. Allied Chemical flexibility for shipping ammonia in barge, tankcar, tankwagon, tank truck or cylinders fits every user's needs for saving time and labor.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475-482 and in Chemical Week Buyers Guide, pages 37-44.

BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION

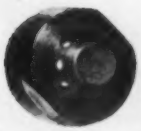
Dept. AA17-6-2 40 Rector Street, New York 6, N. Y.

MEMBER METAL POWDER mpi INDUSTRIES FEDERATION

2819

Circle 1229 on Page 48-8

FOR THE MACHINERY PART THAT TAKES THE BEATING



Critically contoured holes in burner nozzles made of high alloy steel . . . distorted in two days. Mild steel corroded in two hours. But HASTELLOY alloy B nozzles now last several months . . . despite the punishing, high-velocity flow of steam-atomized fuel oils containing sulphuric acid, sulphur compounds, and other corrosive agents.

It's just one more example of why thousands of design and production engineers looking for tough metals for machinery parts . . . specify HAYNES alloys.

If design and production in your field demand really tough metal parts, look into HAYNES alloys. There are more than 15 to choose from, including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

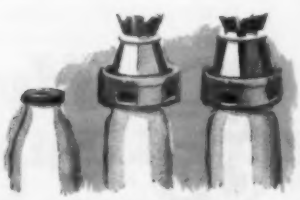
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

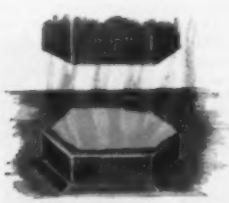
Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL MACHINE PARTS OF ABRASION-RESISTANT "HAYNES" ALLOYS



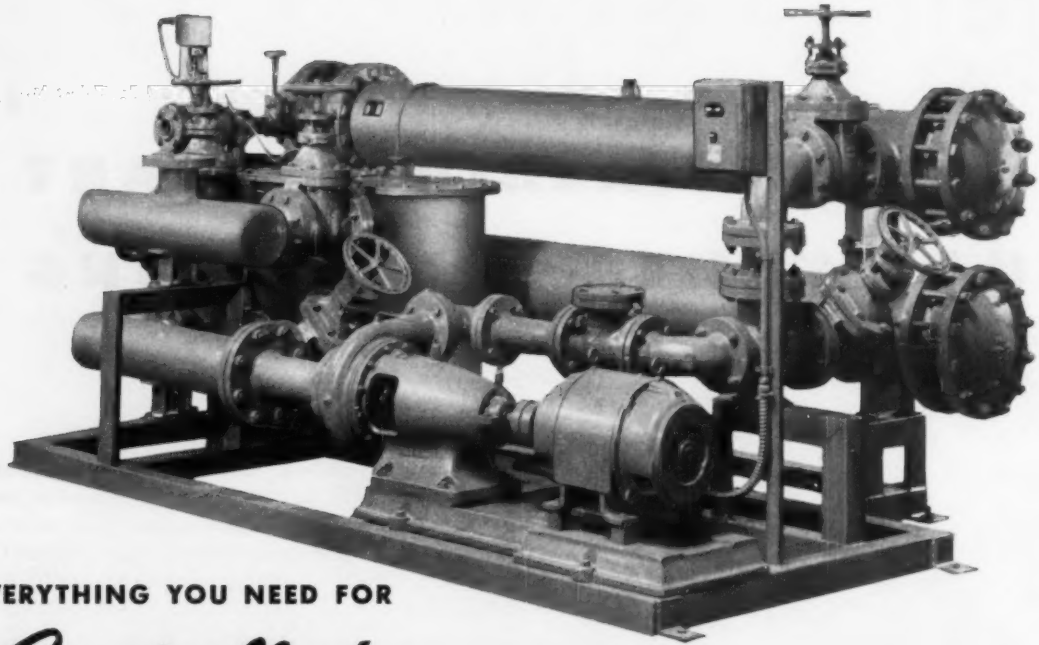
MILK BOTTLE CAPPER sealing-segment fingers, investment cast of HAYNES STELLITE alloy No. 6, capped 100-million bottles in five years without noticeable wear.



DIE LINERS cast from HAYNES 93 alloy have worn only 0.015 in. while making 20,000 bricks from highly abrasive materials, far outlasting other metals.

HALF BUSHINGS made of HAYNES STELLITE alloy No. 6B are used as can headers of a machine that makes 300 milk cans a minute.

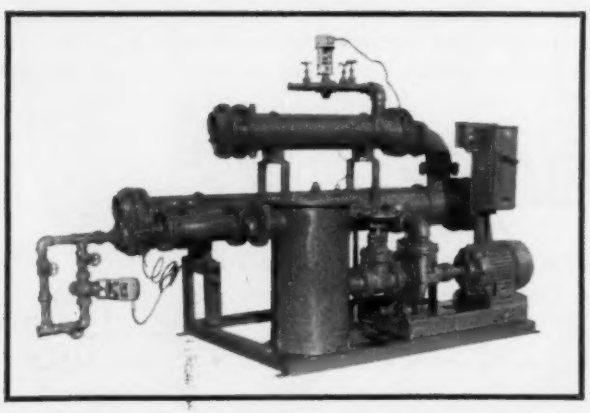
Circle 1230 on Page 48-B



EVERYTHING YOU NEED FOR

Controlled QUENCH OIL COOLING

...EITHER COMPONENT PARTS OR SELF-CONTAINED UNITS



BOTH HEATS AND COOLS QUENCH OIL

This typical B&G self-contained unit, as installed in automotive plant, both heats and cools quench oil to definite temperature specifications.

A B&G Self-Contained Oil Quenching System, factory-engineered and factory-assembled, avoids assembly errors, saves labor costs and can easily be moved if plant layout so demands. Your only responsibility, once the unit is delivered, is to place it in position and connect it to the quench tank and water lines. Or, if preferred, component parts can be furnished for assembly on the job.

This system circulates oil from the quench tank, cools and strains it, and pumps it back at a rate which keeps oil at the right temperature throughout the quench period. Every batch is quenched under identical conditions, hence every batch emerges identical in quality.

With a B&G Oil Quenching System, quenching is automatically controlled and results are predictable. You cut losses resulting from excessive rejects and realize a substantial "inside profit."

B&G Quench Tanks

Properly designed to induce maximum turbulence in the quench oil, B&G Quench Tanks are available in standard models or can be built to meet any specific quenching requirement.

Send for this combined Catalog and Simplified Selection Manual for B&G Self-Contained Quench Oil Coolers.

Hydro-Flo®

OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

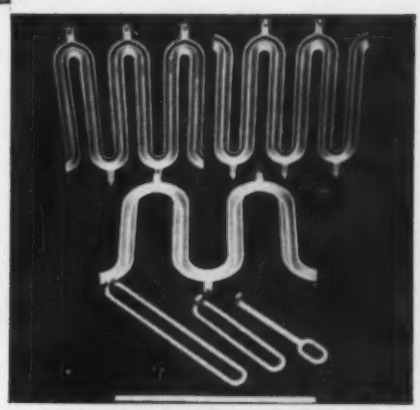
Dept. GI-16, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto 16, Ont.

Circle 1231 on Page 48-B

Duraloy Tubes and Grids *to Meet Exacting* THE ELECTRIC EF FURNACE CO. GAS • OIL • ELECTRIC *Specifications*

Duraloy Centrifugally Cast Tubes 7'9" long, 7" O.D., ⅜" wall. 28 Cr 10 Ni; some of HOM alloy.



Duraloy Resistance Grids—Shell Molded. 18 Cr 38 Ni; some of special HOM alloy.

Heat treating furnaces need high alloy castings...radiant heat tubes for gas or oil fired...resistance grids for electrical...and castings for handling material through the furnace. *And the castings must be fail-proof!*

One reason—indeed the major reason—why The Electric Furnace Company, Salem, Ohio, has leaned so heavily on Duraloy for its castings is that over the years Duraloy Castings have established a fine record for durability and uniformity. And with the recent development of Duraloy HOM, the furnace company can work towards higher temperature operations. HOM can be used quite broadly at temperatures up to 2200°F and in a limited way to 2300°F. It can be cast statically, centrifugally and shell molded.

When such an authority on heat treating furnaces as Electric Furnace so consistently selects Duraloy castings for these furnaces on which it has built an enviable reputation...that preference suggests quite strongly that Duraloy castings are consistently sound and skillfully alloyed to meet exacting high temperature applications. This same skill offers comparable values to all who require high alloy castings.

Annealing furnace designed and constructed by The Electric Furnace Company used for cycle annealing of enameling iron strip and bright annealing of cold rolled strip. Three methods of heating: direct fuel fire; fuel fired radiant heat; and electric resistance used in the various zones.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

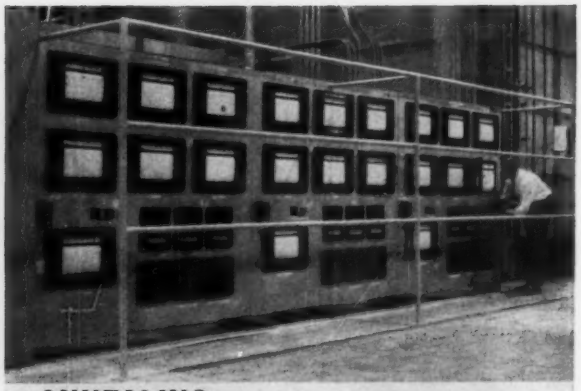
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.

CHICAGO OFFICE: 332 South Michigan Avenue

DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Circle 1232 on Page 48-B

SOAKING. These Bristol Dynamaster* instruments monitor soaking pit operation in new, multi-million-dollar aluminum fabricating plant of Anaconda Aluminum Company at Terre Haute, Indiana. Staff engineer analyzes record.



ANNEALING. Dynamaster* instruments here control and record annealing furnace temperatures in new Anaconda Aluminum plant. Over 11½ acres under one roof, the new plant produces aluminum sheets, extrusions, tubes and ingots.

HEAT TREATING. Anaconda staff engineer checks temperature records, produced by Bristol Dynamaster instruments, for vertical extrusion heat-treating tower, part of which is shown at left.

AGING. Dynamaster instrument panel at left controls and records temperatures in aging furnaces in new Anaconda Aluminum Company plant. Furnace operator at right is moving rack car into furnace.

BRISTOL INSTRUMENTS FOR THE METAL INDUSTRY

The key to higher quality, more uniform production, greater efficiency

Bristol offers pyrometers for every requirement: Electronic potentiometers (including miniature models), millivoltmeter and radiation types... for furnaces, ovens... every type of heating equipment, every kind of fuel.

Bristol Dynamaster* electronic potentiometer pyrometers, service-tested and proved in thousands of industrial plant installations, fully measure up to the requirements of today's most advanced steel and metal-working plants. Check these modern features:

1. Continuous standardization—eliminates usual standardizing mechanism and dry cell... no interruption to control.

2. Simple, modular design—few moving parts.

3. Easy to use and service—minimum maintenance.

4. Rugged construction—continued accuracy and reliability under tough conditions.

Write for complete data—and remember, Bristol markets a complete line of pyrometer accessories available for fast delivery to keep your plant in operation. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn. *T. M. Reg. U. S. Pat. Off.

BRISTOL ... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Circle 1233 on Page 48-E

ALCAN extrusion ingot gives you these 4 dollar-saving advantages!

1. Better finish! 2. Greater extrudability! 3. Higher recovery! 4. Longer die-life! . . . four important reasons why ALCAN extrusion ingot may be far more economical than the billet you're now using!

How much will this better quality billet save? For an exact answer test-run ALCAN billet on your own equipment. Carefully measure its performance and true cost. See how much easier and faster it extrudes. How it reduces scrap and lengthens die-life. How it actually makes a difference in the quality of your finish.

From mining to casting—countless checks on quality make ALCAN the finest of all billet products. It is made entirely of clean, primary metal . . . unexcelled in internal structure and surface smoothness . . . and cast to the industry's closest tolerances.

Telephone our nearest office today about testing ALCAN billet on your own equipment! We welcome the opportunity to show you the difference it can make in your extruding costs and productivity.

Aluminium Limited ALCAN

Ingot Specialist...serving
American Aluminum Fabricators—

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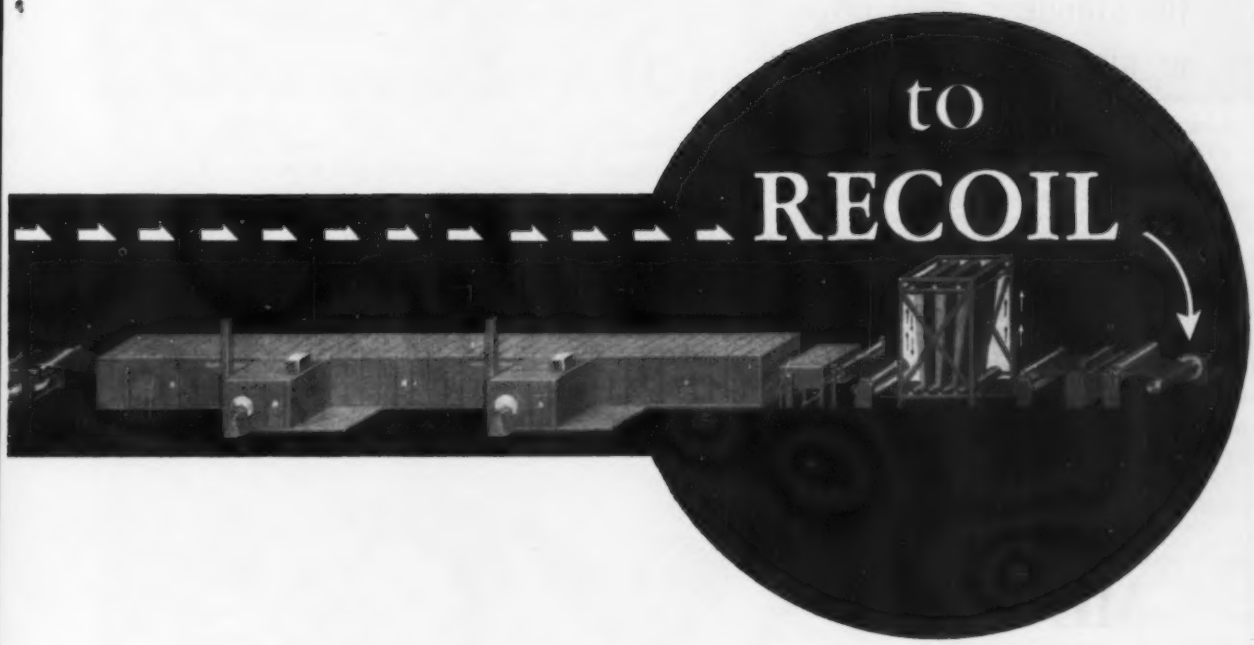
Additional distribution (Alcan Foundry Alloys):
Apex Smelting Company, Chicago, Cleveland, Los Angeles
Aluminum Inc., Fort Lauderdale, Florida

Circle 1234 on Page 48-B

THE ROSS/WALDRON STRIP COATING LINE

high production machinery for quality coating of aluminum and steel strip

Plan now to visit us at Booth 1540 at the Metal Show. We will be glad to give you all the latest information on metal strip coating.



Selecting a Ross/Waldron Strip Coating Line for aluminum, steel, tin plate or any other metal means you have a *single source* responsible for the complete line. Every piece of actual processing equipment is made to the same uniformly high specifications. There are no weak links. Result? Less down-time—more production and the highest quality.

Write for Bulletin RW-500, or our reprint entitled "Continuous Coating of Aluminum or Steel Strip."

M-R

J. O. ROSS ENGINEERING
WALDRON-HARTIG

DIVISIONS OF MIDLAND-ROSS CORPORATION
730 THIRD AVENUE, NEW YORK 17, NEW YORK

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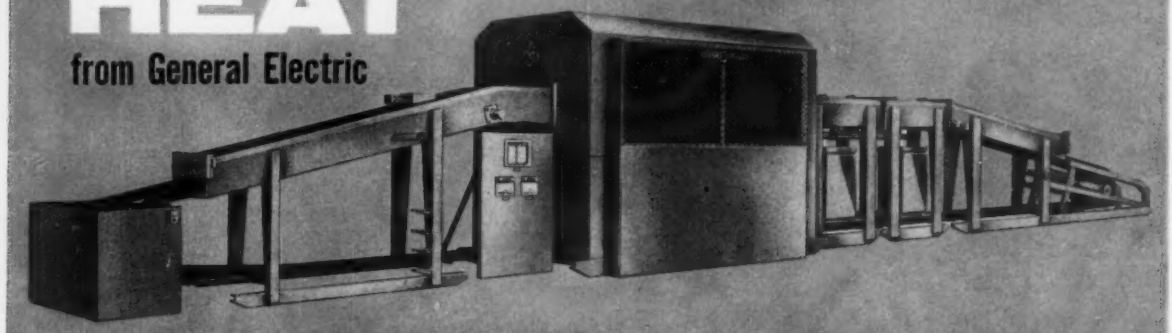
Circle 1235 on Page 48-B

HEAT
from General Electric



for stainless steel bright brazing, heat treating, or sintering to 2200 F

NEW Muffle-less Mesh-belt Furnace from General Electric maintains high purity atmosphere and high temperature needed to treat stainless steel parts in continuous production. Performance is excellent: dewpoints of below −50 F have been maintained under production conditions. Rapid heating, high heating rates, maximum loading add up to increased production. Your operating costs are less because of reduced heat loss and cooling water, fewer rejects, hydrogen conservation. Key to reduced maintenance is there's *no muffle to replace.* Other factors: long-life belt and molybdenum heating units; easily cleaned cooling chambers.

Circle 1236 on Page 48-B

Ask your General Electric Sales Engineer for complete data on the new G-E Hump Mesh-belt Furnace or write for bulletin GED-3990. General Electric Company, Schenectady 5, N. Y.

721-28

Progress Is Our Most Important Product

GENERAL ELECTRIC

MAN, METALS AND MODERN MAGIC

METALS
yesterday—
today—
tomorrow.

a fascinating ASM book

by Dr. J. Gordon Parr

This is a book for technician and student alike to enjoy—a story of metallurgical progress through the ages to the challenging problems of science that must be solved tomorrow. Enjoyable reading—an ideal gift.

15 Chapters...44 Illustrations...235 Pages...$2.95
Red Cloth Binding . . . Published April, 1958

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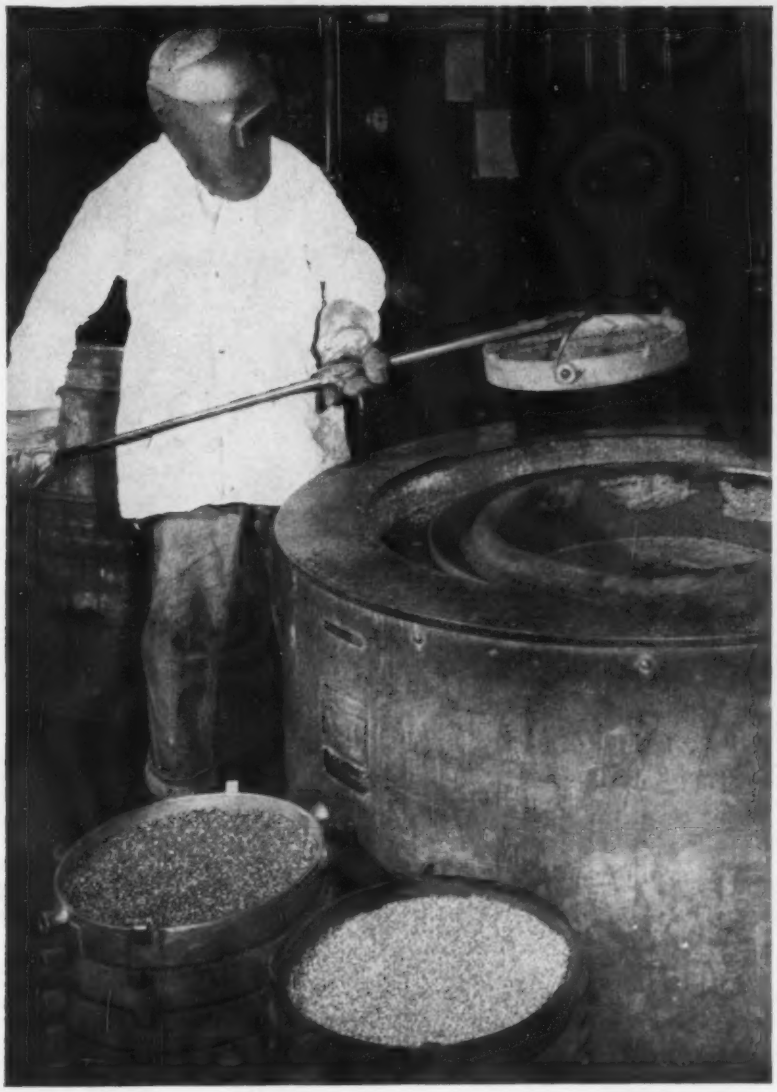

Trays resist carburizing and thermal fatigue. Trays shown here are repeatedly exposed to 1650°F for 4 hours, then water quenched. Made of Type "HX" cast alloy containing 66% nickel, 17% chromium, they display excellent ability to withstand cycling without cracking or severe warping. High nickel alloys such as this are outstanding in their resistance to thermal shock and fatigue.

Through day-in, day-out cycling punishment...

High nickel alloys laugh at high temperatures

Are you looking for a way to outwit thermal fatigue?

Then you'll want to know more about the reliable high temperature alloys available to you.

There are 12 basic types of nickel-chromium-iron alloys that give useful strength and long life to castings subject to a wide variety of potentially destructive environments.

You name the service...temperatures ranging from 1200°F to 2200°F... reducing or oxidizing conditions... nitriding or carburizing atmospheres.

Under all these conditions, the appropriate nickel-containing alloys give good accounts of themselves in everything from trays and racks to tubes and retorts...from baskets and bearings to fans and fixtures.

They come feature-packed. Nickel-containing alloys provide you with heat-resisting castings having good creep strength and high resistance to scaling...thermal fatigue...thermal shock...sigma phase embrittlement.

Making your choice. Of course, the proper selection of an alloy for any specific high temperature job involves consideration of many factors, including:

- Required size and shape of the part
- Type and size of maximum load
- Speed and range of temperature cycling
- Atmospheres and contaminants
- Complexity of design
- Additional fabrication needed

You'll find lots of valuable—and usable—information on the proper selection of casting materials in our new 64-page, illustrated booklet, "Heat Resistant Castings, Corrosion Resistant Castings...Their Engineering Properties & Applications." We'll be glad to send you a copy on request. *Write for it — today.* Just ask for Bulletin A-266.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Circle 1247 on Page 48-B

PART: Welded bellows-type seal. **MATERIAL:** Type 410 Stainless Steel. **SPECIFICATIONS:** To be hardened under close control because of variations in metal sections. Finished assembly to be clean, bright and free from oxides and scale. Seal in photo has been cut to show cross section of the bellows-type seal.

How would you heat treat a part like this?

The stainless steel bellows-type seal shown is used in a number of applications, from refrigerating systems to missiles, where mechanical seals are needed to resist extreme temperatures from —400F to +1200F. Heat treatment is complicated by the wide variation in section between the thin bellows and the much heavier outer rings.

The Sealol Corporation, Warwick, R. I., solves the problem with a Hayes electric furnace equipped with GLOBAR® silicon carbide heating elements. Depending on the material of the welded bellows (stainless steels of the 300 and 400 groups, precipitation hardened steels such as AM350, 17-7PH, Inconel X, etc.), hardening is between 1700F and 1900F, followed by muffle cooling, both in a hydrogen atmosphere.

GLOBAR elements make possible the precise temperature control and clean heat, independent of the atmosphere, required in this critical operation. Rod-type element simplifies design, furnace construction and servicing. Losses are minimized because all heat is produced and contained inside the furnace.

The many advantages of heating with GLOBAR elements often more than cancel out differentials in BTU costs between electricity and other fuels. Why not investigate with your furnace builder—or write to Refractories Division, Globar Plant, Dept. MP-90, The Carborundum Co., Niagara Falls, N. Y.

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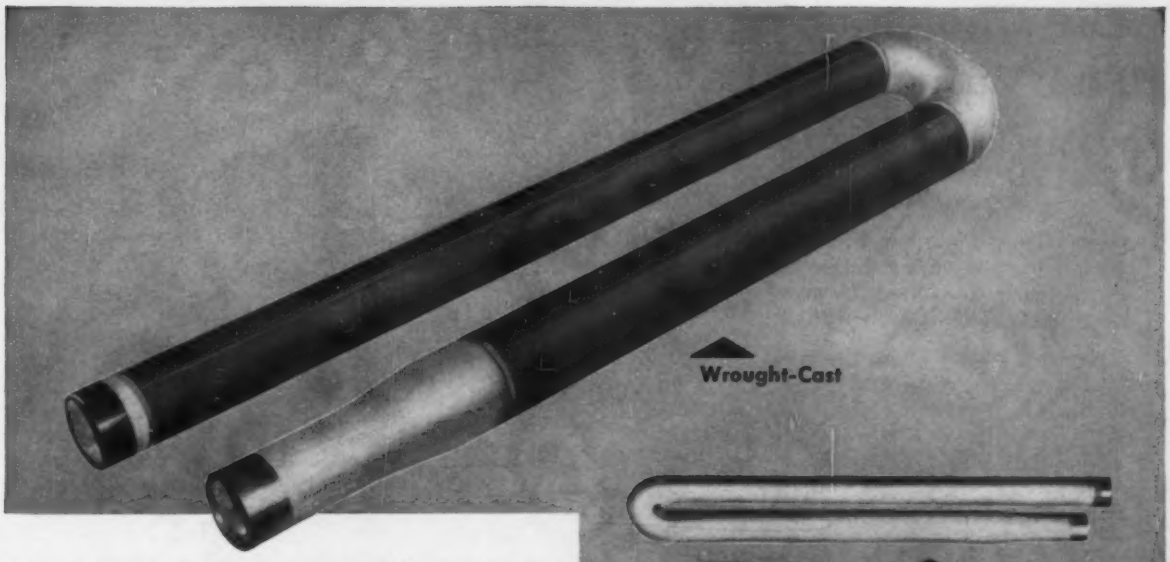
GLOBAR silicon carbide heating elements

- Shipped from stock or within two weeks.
- Temperatures from 1400 to 2800 F, precisely controlled, independent of atmosphere.
- Easily replaced from outside without waiting for furnace to cool.
- "On line" operation for many applications—no transformer necessary.
- Rods 4" to 105" in length.
- For greater economy in heat treating, brazing, forging, melting, and sintering.

Circle 1248 on Page 48-B



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General Alloys Company is unique as a major producer of *both* castings and fabrications and therefore can recommend, without bias, the type of construction best suited for your needs.

For complete data, quotes, or engineering service contact the office nearest you . . . or write General Alloys Company, 401 West First Street, Boston 27, Massachusetts.

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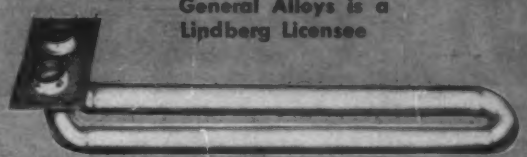

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Circle 1249 on Page 48-S

The Choice is Wide, The Value is High with Hevi-Duty Furnaces

Here are three users of melting and holding furnaces. They represent three methods of casting, using either fuel-firing or electric resistance heating, yet each has found the answer to his needs at Hevi-Duty. This is not surprising.

Hevi-Duty now offers the widest choice of heat processing furnaces — both electric and fuel — in the industry. This is important in terms of furnace value. It means you can probably find a proven unit that fits your needs exactly.

Why not consult a Hevi-Duty Sales Engineer soon? Let him show you why a wide choice means a high value in furnace equipment.

HEVI-DUTY

Electric and Fuel-Fired Industrial Furnaces and Ovens

B P C

A Division of Basic Products Corporation

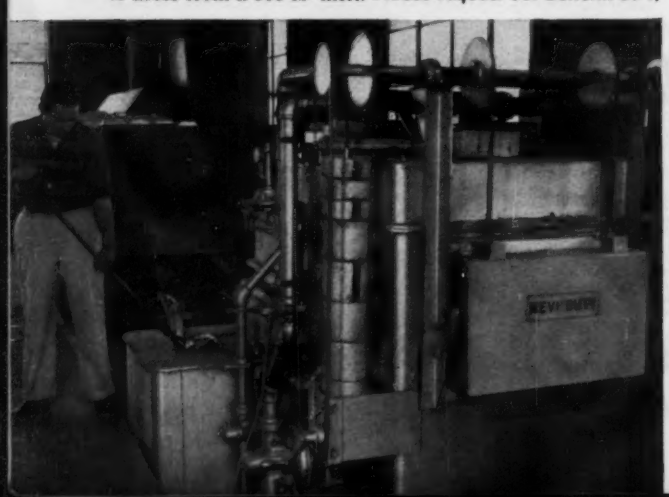
Hevi-Duty Electric Company, Milwaukee 1, Wis.

Circle 1160 on Page 48-B

This electric crucible furnace is used by Baso, Inc., Milwaukee, Wisconsin, for holding aluminum at 1240°F. Baso casts components for controls for all types of gas burning equipment from permanent molds. Circular design allows three dip-out stations. There are no exhaust fumes, no bath turbulence, and exterior shell remains relatively cool. ***For complete information on this furnace, write for Bulletin 591.***

A gas-fired, double chamber dry hearth furnace is used for die-casting electric frying pans at the New England Die-Casting Company, West Haven, Conn. Aluminum melts on a sloping hearth and runs into a dip-out chamber where it remains at constant casting temperature. Moisture and volatiles escape during heating. Foreign materials remain on the hearth. This assures clean, high-quality metal on a production line basis. ***Please write today for Bulletin 594.***

Elm City Pattern and Foundry Works, Branford, Conn., uses this dry hearth furnace for sand casting aluminum. Mr. Hal Burkehard, Foundry Manager, likes the way the thermocouple control holds the bath at uniform temperature. He reports that this unit produces cleaner castings than do their other furnaces . . . that he gets only a handful of dross from a 500-lb melt. ***Please request our Bulletin 594.***



Circle 1251
on Page 48-B

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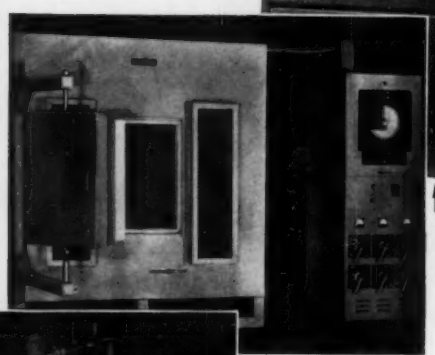
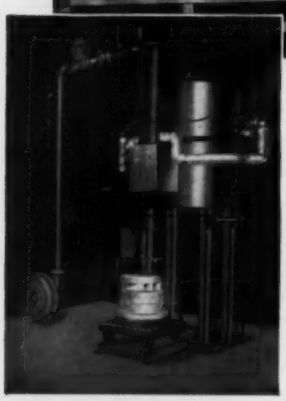


Electric — MR Series, Metallic Resistors; radiation or convection heating



Electric — NMR Series, Non-Metallic Resistors; cabinet, box, tube, elevator types

Gas-Fired — floor or elevator types

When you require *controlled* application of heat . . . in research, testing or small-parts manufacturing . . . Harrop experience can guide you to the selection of the most serviceable furnace. Chances are there's a *standard* Harrop model that will meet your needs. But it's routine for Harrop to equip a standard furnace with almost any combination of *special instrumentation* for exacting specific procedures. And the first-time-ever assignment is readily undertaken by its design engineers and production experts.

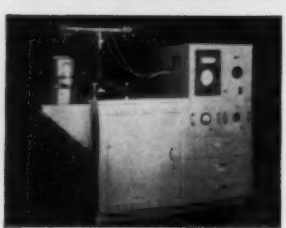
To suggest the scope of Harrop's experience and ability to serve your requirements for the precision *controlled* application of heat:

Firing — electric or gas

Temperatures — up to 4,200° F. (and higher if required), in controlled atmospheres

Instrumentation — for any need, both in respect to control and to control forms affecting the time-temperature-atmosphere relations

Setting Space — in diverse form to meet specific need, in shape and size and in mechanical and electrical accessories



Representative of Harrop ability to do the unusual is this interferometer.

For Non-Obligating Recommendations, send information on materials, temperature range, heat control, firing objectives to Dr. Robert A. Schoenlaub, Technical Director, Harrop Precision Furnace Co., 3470 E. Fifth Ave., Columbus 19, Ohio

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Dept. M (formerly Harrop Electric Furnace Division) A Division of Harrop Ceramic Service Co.

Circle 1252 on Page 48-B

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Write for Seymour's Alloy Selection Chart

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Circle 1253 on Page 48-B

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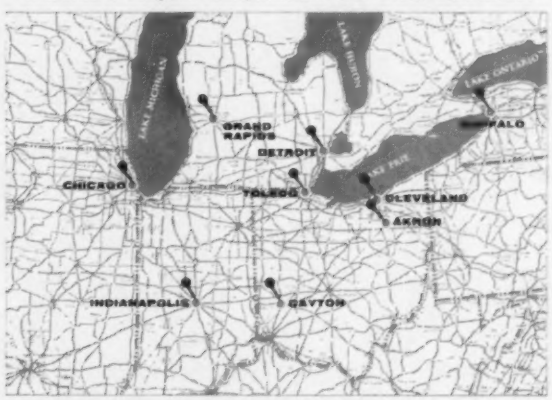

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Circle 1254 on Page 48-B

WHICH MAN IS MORE LIKELY TO SUCCEED?

How you spend your spare time can affect your future.

What MEI students say:

"The course was very beneficial and I feel because of it, I was offered a better position."

"Thanks to your course, I have taken over the job of my previous supervisor."

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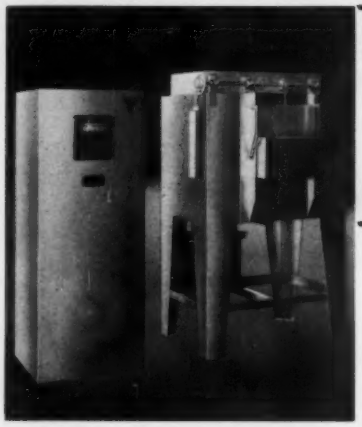
Circle 1255 on Page 48-B

Capable of *Continuous Operation* at temperatures to 1600 degrees C.



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Circle 1257 on Page 48-B

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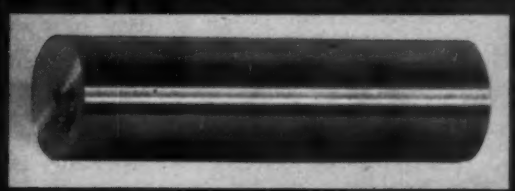

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Melting Point °F	1720
Boiling Point	6420
Electrical Resistivity (55 F)	70.0
Thermal Conductivity (55 F)	8.1
Thermal Neutron X-section	11.2
Ultimate Tensil Strength psi	16,000
Yield Strength (as cast) psi	15,000
Ductile, Machinable	

For further information send for brochure.

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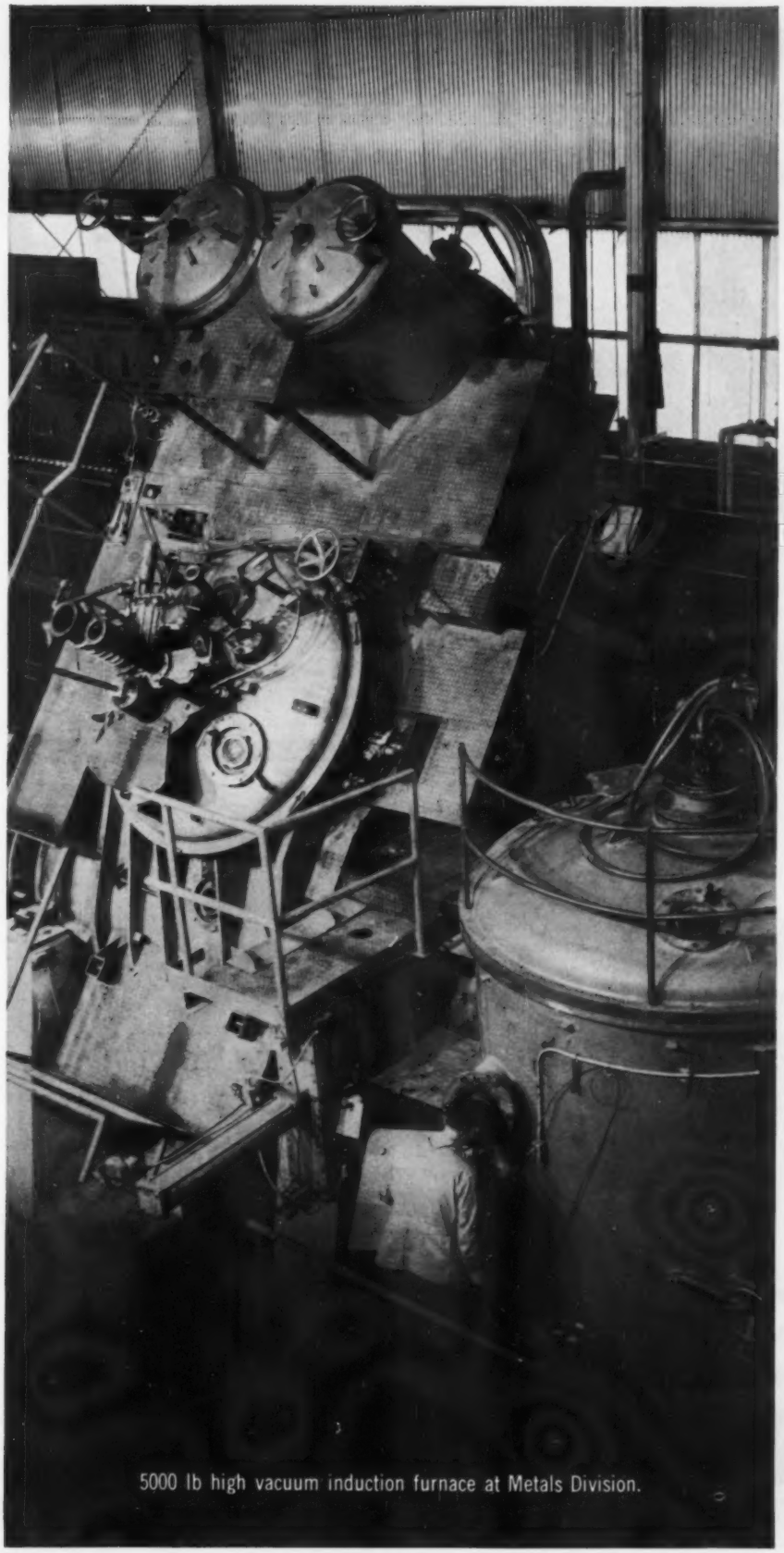
Circle 1256 on Page 48-B



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Circle 1258 on Page 48-B

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Circle 1259 on Page 48-B

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Circle 1260 on Page 48-B

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Circle 1261 on Page 48-B

Destination Philadelphia October 17

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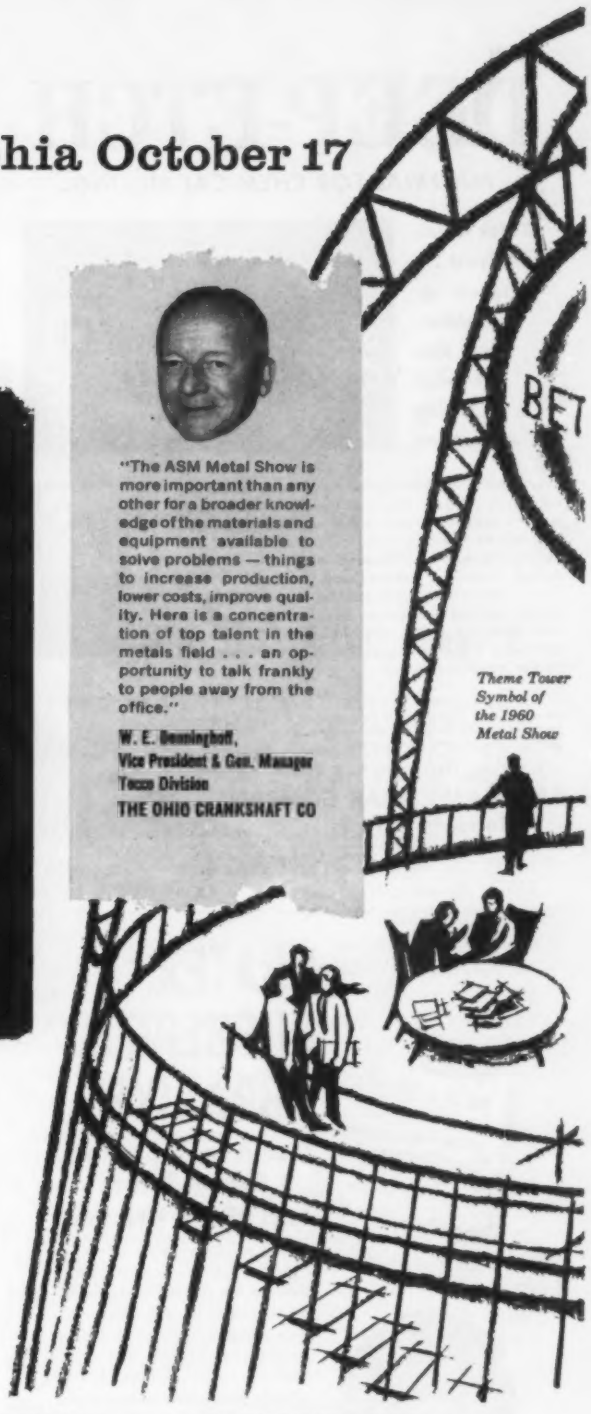

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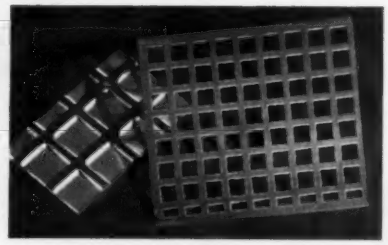

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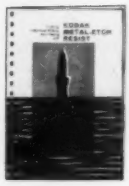

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EASTMAN KODAK COMPANY

Rochester 4, N. Y.

Kodak

Circle 1262 on Page 48-B

re-li'a-ble: That which can always be counted upon to do what is expected or required

CRATEX RUBBERIZED ABRASIVES

Micro-deburring, Smoothing, Cleaning, Polishing

Cratex reliability lowers costs

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WHEELS • POINTS • BLOCKS • STICKS • CONES in 4 grit textures for power or manual application. Sold through leading industrial supply distributors.

FREE! *Send for the complete CRATEX Industrial Catalog today*

CRATEX

MANUFACTURING COMPANY, INC.

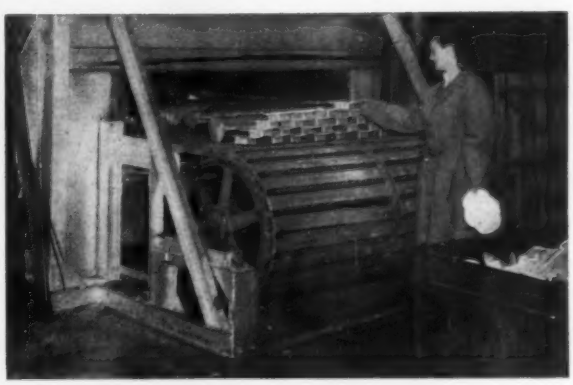
1600 Rollins Road Burlingame, California

Circle 1264 on Page 48-B

COLUMBIA TOOL STEELS

SUPERDIE (type D3) high carbon high chromium steel is your easy answer to hard die problems

Product of Skilled American Workmen



Continuous Conveyor Type ALUMINUM BILLET HEATING FURNACES

One of two furnaces installed at Harvey Aluminum, Torrance, California, heats 2500 pounds of aluminum billets per hour to 1000° F. Furnace is six feet wide and incorporates an automatically operated, direct gas fired recirculating heating system. Temperature uniformity guaranteed.

Ask for Bulletin HT-53.

THE carl mayer CORP.

20800 CENTER RIDGE RD. CLEVELAND 16, OHIO

OTHER PRODUCTS: Core & Mold Ovens • Rod Bakers • Paint and Ceramic Drying Ovens • Special Processing Equipment & Accessories

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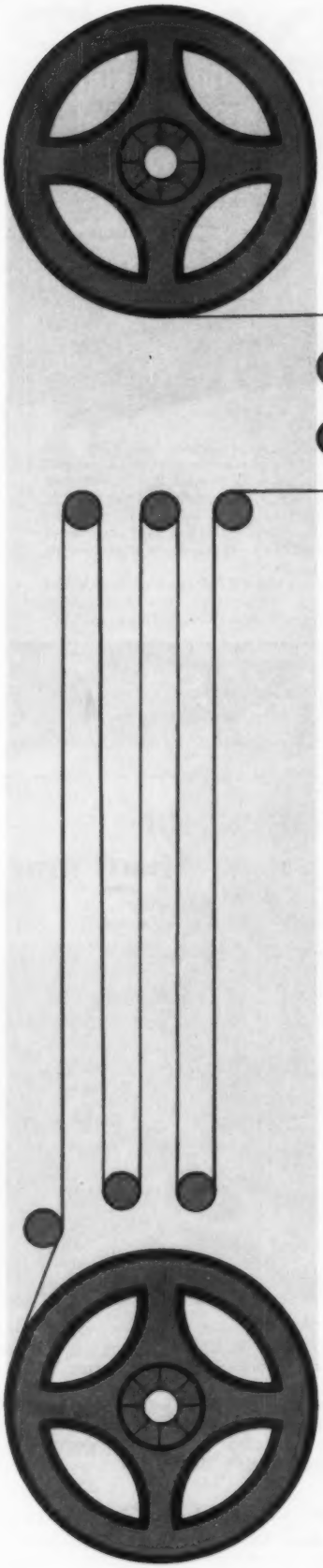

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- REDUCES WEAR-IN TIME AND DAMAGE IN NEW OR REBUILT MACHINERY
- THE HIGHER THE LOADS, THE GREATER THE MARGIN OF SUPERIORITY OF MOLYKOTE G

Write for your free sample of MOLYKOTE G LUBRICANT today. We will also send you a copy of our new Bulletin 126 which gives complete details. THE ALPHA MOLYKOTE CORPORATION, 65 Harvard Avenue, Stamford, Conn. Phone Fireside 8-3724. Plants in Stamford, Conn., Munich, Germany and Strasbourg, France.

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COMPANY_____
ADDRESS_____
CITY_____ ZONE____ STATE_____

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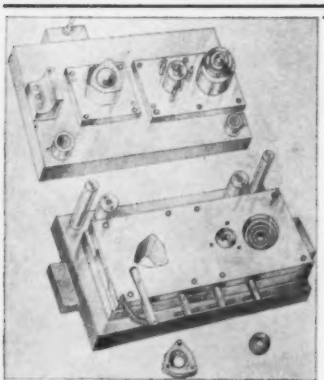

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Ziv's Hargus Oil Hardening Tool Steel

Use it with confidence for blanking, forming and drawing dies.

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This HARGUS Die blanks and forms Ring Bushing Clamps.

●

Material: 3/16 Hot Rolled, Pickled.

●

Progressive four stage die with scrap cutter.

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Average run approximately 40,000 pieces per grind.

Free literature and expert personal attention upon request.

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ESTABLISHED 1911

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High Grade Tool Steel

ZIVCO TRADE MARK

BUTLER, WIS. DETROIT, MICH. EAGLE RIVER, MICH.
INDIANAPOLIS, IND. ST. LOUIS, MO. TOLEDO, O.
2945 W. HARRISON STREET - - - - - CHICAGO 12, ILL.

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REVCO

ULTRA-LOW TEMPERATURE CABINETS

for

- Research
- Storage
- Seasoning
- Testing

Seven Revco cabinets, both chest and upright styles, are available. Capacities range from 1.5 to 6 cu. ft. in chests and to 22 cu. ft. in uprights. Units provide temperatures to −140° F. controllable within ±1°. Optional accessories are offered. Immediate delivery on all units.

For your FREE copy of the helpful folder, "Selecting a low temperature cabinet," write Revco, Dept. MP-90.

Industrial Products Div.,
REVCO INC.
Deerfield, Michigan
Setting Trends in Refrigeration Since 1938

Circle 1267 on Page 48-B

THE MARK OF QUALITY
BARBER COLMAN

Impressor

PORTABLE HARDNESS TESTER

- Rapid testing — no setup
- Easy to carry and use
- Needs only space for hand

A portable hardness tester for brass, copper, aluminum, other soft metals, and plastics, the Barber-Colman Impressor is designed for fabricated parts and raw stock testing. Operating experience is not essential. The reading is instantly indicated on the convenient dial. No waiting, preloading, or separate measurements. Barber-Colman engineers will gladly recommend the most suitable model for your application. Write today for complete details.

BARBER-COLMAN COMPANY
Dept. I, 1218 Rock Street, Rockford, Illinois

Circle 1269 on Page 48-B

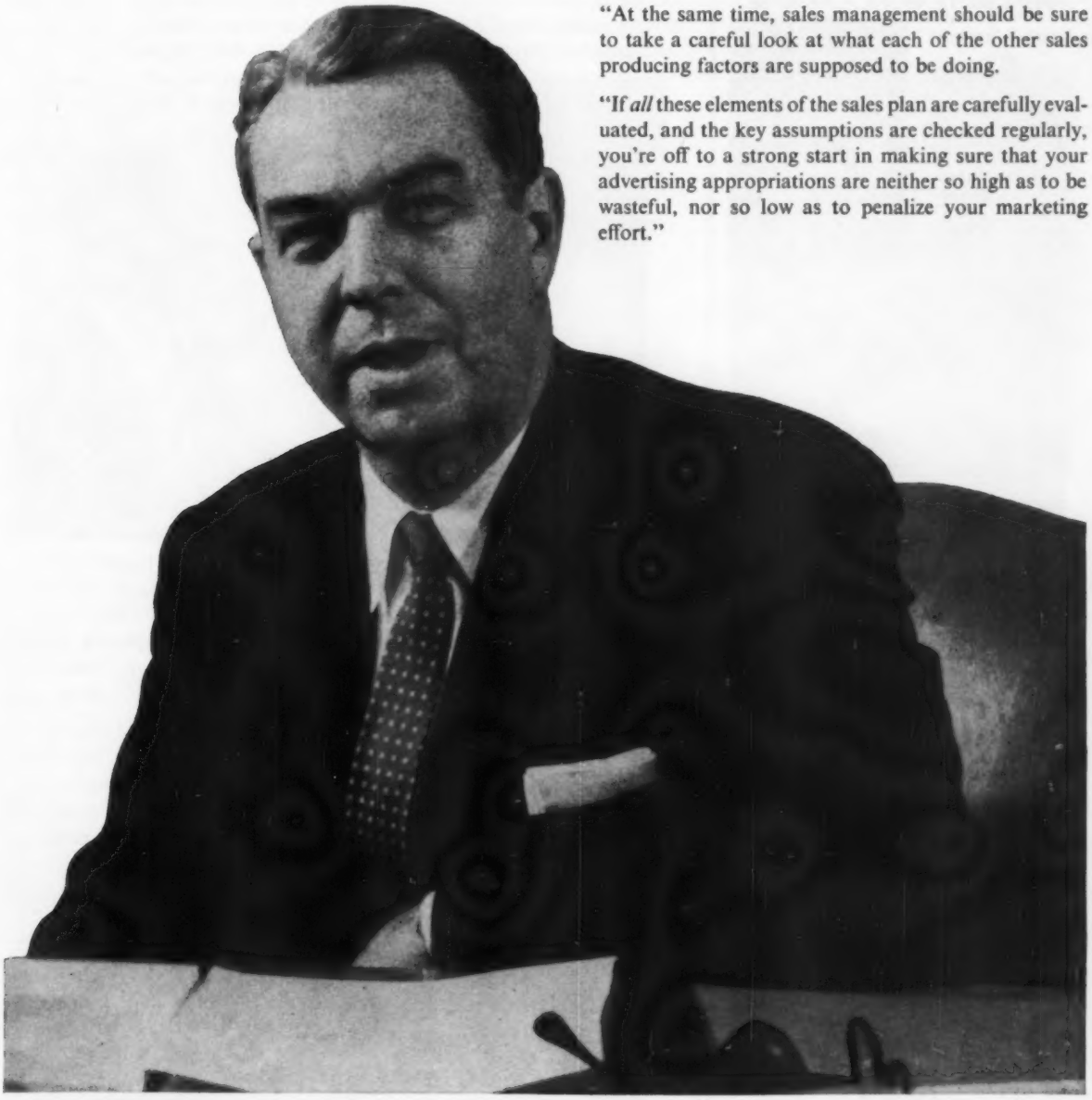
"How much is enough for advertising?"

JOHN R. SARGENT, partner in the nationally-known management consultant firm of Cresap, McCormick and Paget, points the way toward solution of one of top management's knottiest problems.

"Good sales management generally knows the crucial sales problems faced by each one of its products. Through good advertising advice plus experience, trial and error, and some judicious advertising testing, sales management also can come to have a good understanding of what advertising can and cannot do.

"At the same time, sales management should be sure to take a careful look at what each of the other sales producing factors are supposed to be doing.

"If *all* these elements of the sales plan are carefully evaluated, and the key assumptions are checked regularly, you're off to a strong start in making sure that your advertising appropriations are neither so high as to be wasteful, nor so low as to penalize your marketing effort."



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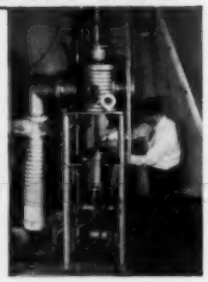
NEWS from the NRC Vacuum MICRONICLE*

PURER METALS WITH ELECTRON BEAM



Hard to melt materials such as tungsten, tantalum, zirconium, molybdenum, columbium and other high performance metals can now be melted without contamination. Electron beam technique can be used for either melting or contamination-free welding.

These furnaces can operate at highest vacuums attainable in a furnace and melt stock in any form. Melting temperature is almost unlimited. Heating can be concentrated or spread out as desired.

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DEcatur 2-5800

NEO-19

BEHIND THE BYLINES

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"Residual Elements in Steelmaking", leading off our Steel Technology on the Move section this month (p. 69), is based on a talk presented before the Birmingham Chapter by F. C. Langenberg, one of the co-authors. He and J. F. Johnston are both on the staff of Crucible Steel Co. of America, the former as manager of process research and the latter as staff metallurgist. Mr. Langenberg (shown, right, in the photo below, without Mr. Johnston, who is presently assigned to a different company location) received his bachelor's and

master's degrees in metallurgical engineering from Lehigh University and his doctorate in metallurgy from Pennsylvania State University. He joined Crucible in 1955.

Mr. Johnston joined Crucible in 1959 after receiving his bachelor's degree in industrial engineering from Geneva College. Now staff metallurgist, he has worked in the central research laboratory and the mill metallurgy department at the Midland Works.

"Revealing Lead Inclusions in Leaded Steels" is discussed on p. 77 by Gladys Chalfant, assistant technologist in U. S. Steel's Research Laboratory in Monroeville, Pa. A graduate of Waynesburg College, she worked as a metallographer at the Glenn L. Martin Co. before joining U. S. Steel in 1947. She was assigned to the carbon bar and semifinished products section, where she became interested in the metallographic study and evaluation of the effect of inclusions and microstructures on the machinability of steel.

As a member of the Society of Women Engineers, she participated in the planning and staging of the national convention held in Pittsburgh last year. An avid golfer, she shoots in the high 90's. And when not on the golf course, she gardens, sews and works on do-it-yourself projects around her newly acquired home.

J. H. Waxweiler, in the photo below, is holding a piece of honeycomb core – the product of the foil described in his article on "Surface Film Studies on Bright Annealed 17-7 PH Stainless Steel" (p. 80). Stainless has been the subject of his work at the research

laboratory of Armco Steel Corp. for 14 years, where he is now senior research engineer. A graduate with a degree in engineering from Iowa State University, he spent three years in the Navy during World War II. During his leisure hours, he can usually be found on the golf course – summer *or* winter. Another interesting diversion – playing tympani for the Middletown Civic Symphony Orchestra.

The author of "Silicon Irons Up to Date" (p. 84), Weston Morrill, is shown at left with G.E.'s equipment for measuring magnetostriction of silicon steel samples, discussed in his article. A graduate of Worcester Polytechnic Institute (with a bachelor's and master's degree in chemistry), he spent four years as a chemical engineer for Guggenheim Bros. Laboratories in New York and Anglo-Chilean

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D.E.W.* Line

with Sonoray® and Sonogate

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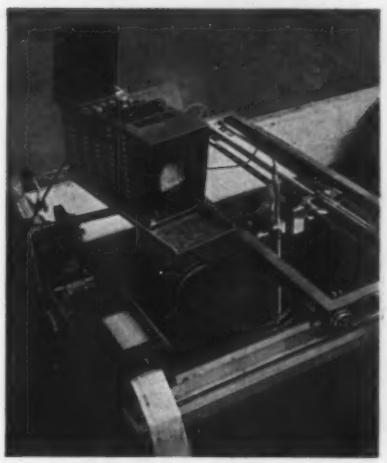
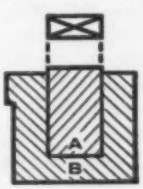
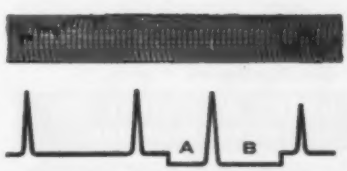


Early warning of internal defects prevents further waste of time and money on materials and parts that would later be rejected or fail in service / Here, for instance, a *Sonoray*® Ultrasonic Flaw Detector with accessory Model B *Sonogate* Flaw Alarm, immersion-scans a vital bi-metallic rotary seal. Every variation in bond between the two dissimilar materials is revealed on the CRT and strip-recorded as the part rotates on the submerged turntable / This is just one of the many DEW* techniques available with Branson Ultrasonic Flaw-Detection and Thickness-Gaging equipment. State your problem in detail when requesting further information.





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INSTRUMENTS, INC.

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petroleum catalyst
stainless alloys
organic chemicals
steel
iron
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Determine carbon content in just 2 minutes! No complicated mathematics; eliminates costly time-consuming routines. Accurate analysis of borings, mill chips, crushed samples, pellets, etc. Widely used in industrial, commercial and research laboratories.

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Behind the Bylines . . .

Consolidated Nitrate Corp. in Chile before joining G. E. in 1929 as section head of the Pittsfield laboratories. In 1954 he was named manager of the metallurgical laboratory and last year manager of metallurgical materials engineering.

His sparetime activities include church work and photography — he is a past president of the Berkshire Museum Camera Club.

Resistance to stress-corrosion cracking in materials for naval aircraft is one of the prime concerns of Douglas Aircraft Co.'s El Segundo, Calif., Div., where Robert H. Gassner has been chief metallurgist since 1955. Mr. Gassner, who reports the A.I.M.E. Southwest Metals and Mineral Conference, is shown evaluating a stainless steel bomb hook. During the past 12 years, he has worked on metallurgical problems associated with such aircraft as the AD Skyraider and the A4D Skyhawk.

His chief leisure activities are golf and rooting for the Dodgers — and he often does both simultaneously by means of a transistor radio in his golf bag. As it works out, the Dodger victories usually correlate with lower golf scores.

"Heat Treating Large Steel Castings" is the output of two castings experts, Thomas Ditchfield and Robert G. Waite, shown below, left to right, checking a spectrometer. Mr. Ditchfield started with General Castings in 1934 as a clerk in the rate department, rising to superintendent of the mechanical department where he is responsible for the function of plant engineering, the installation and

maintenance of plant equipment and facilities. Mr. Waite, after receiving his degree in metallurgy from Lehigh University, joined General Steel as a technical engineer in 1940, and since 1951 has been plant metallurgist.

A family man (he has two children), Mr. Waite lists stamp collecting and sailing as his secondary interests. He specializes in United States issues and boasts an over-all collection of more than 40,000 stamps. His fair-weather hobby is sailing his 11-ft. Sea Scouter on the small lakes of northeastern Pennsylvania. Mr. Ditchfield's interests center on his family (a wife and three children) and his church – he has served as church councilman and is presently superintendent of the church school.

"Chemical Conversion on Metal Surfaces for Improved Corrosion Resistance" (p. 101) was written by Robert F. Ayres and based on his work as section head of the chemical research department of Oakite Products, Inc., New York, where his primary concern was the physics and chemistry of metal surface conversion and corrosion inhibition. Now technical director of Dunham Chemical Co. in Chicago, a subsidiary of Chemetron Corp., he is in charge of the expanding research and development program. A graduate in chemistry of New York University, he did several years of graduate work at the Polytechnic Institute of Brooklyn, specializing in metallurgical studies.

The problems met and solved by Grumman Aircraft engineers in the fabrication of an arresting hook for the Navy's S2F-1 Tracker, which not only needed high strength but low magnetic permeability, are described by Albert R. Mead in his article on p. 117. Mr. Mead (shown left) came to the company in 1950 as chief metallurgist and last year was named to the manufacturing vice-president's technical staff. A graduate of New York University, Hofstra College and Stevens Institute's Graduate School of Metallurgy, his education was interrupted by a five-year stint in the U. S. Army as a machine gun squad leader, where he received several decorations, including the purple heart.

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- Ultra-thin (less than 0.0015 in.) with no integral leads, for high flexibility and conformability.
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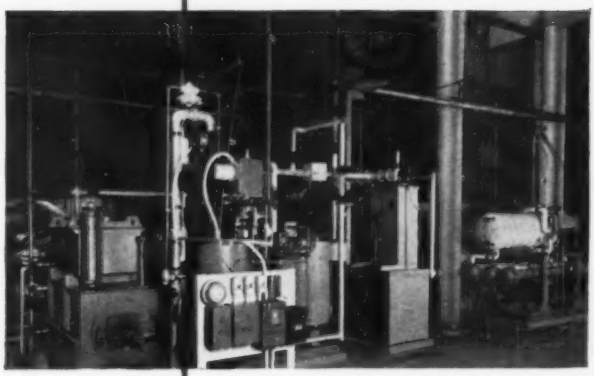

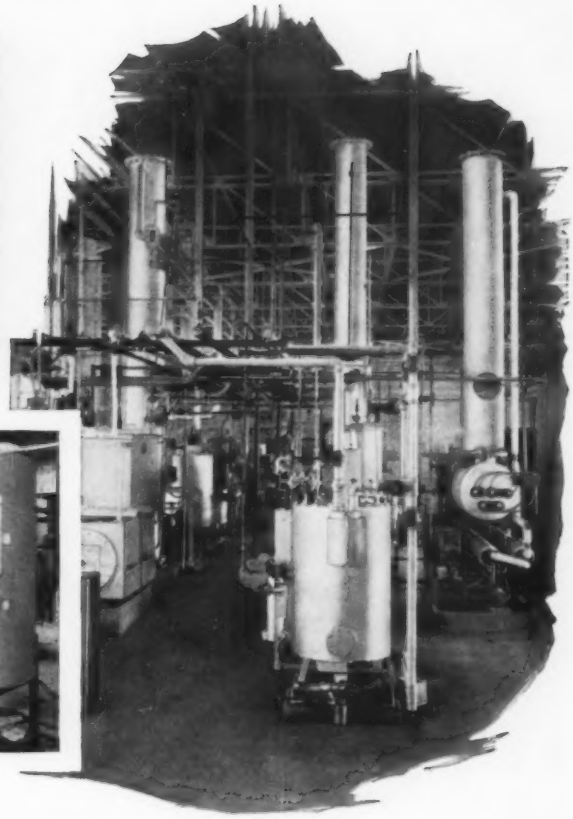

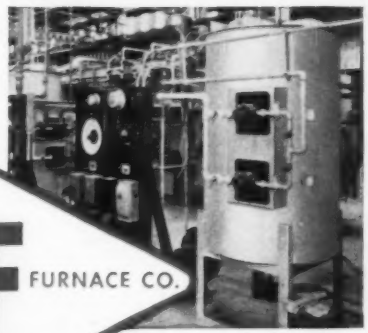

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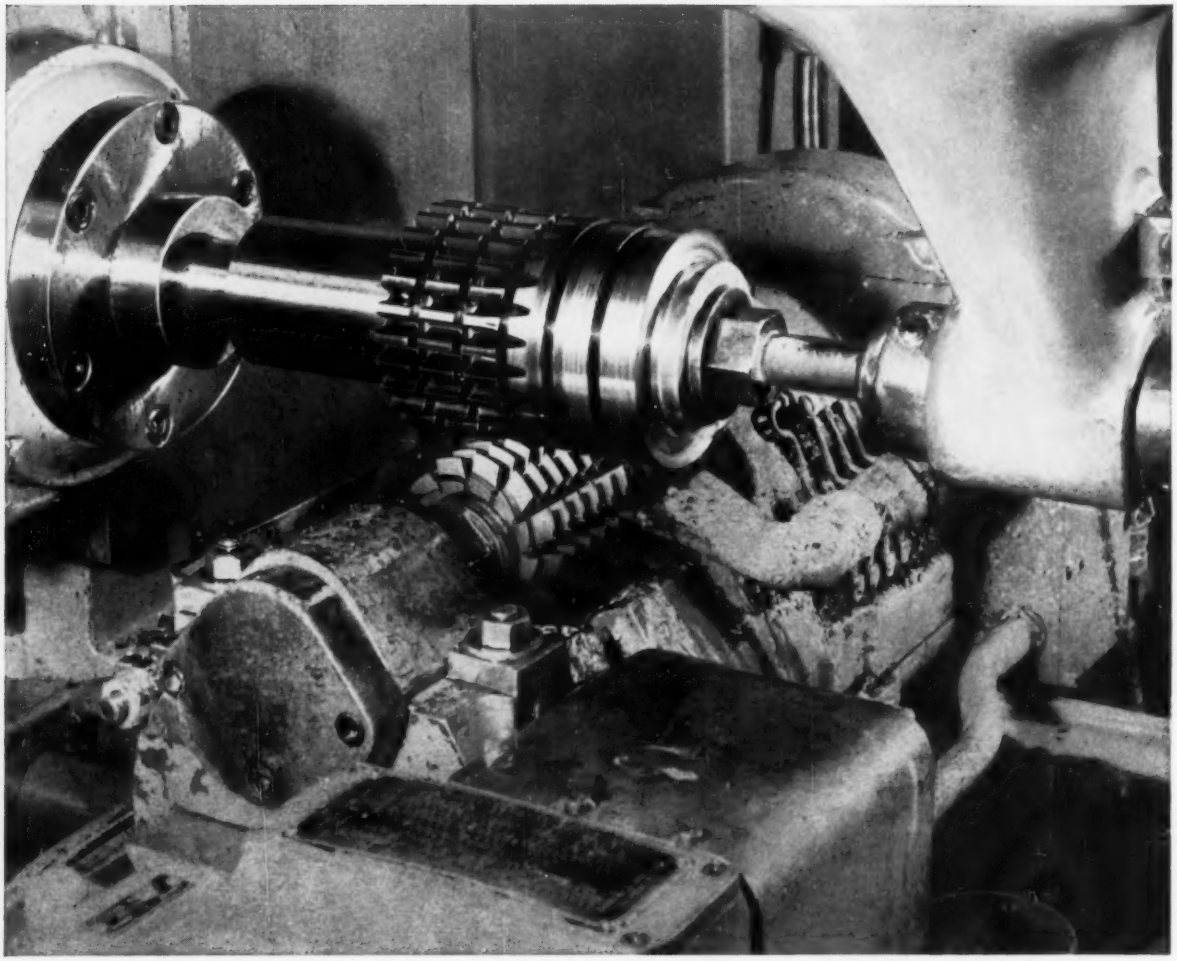

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